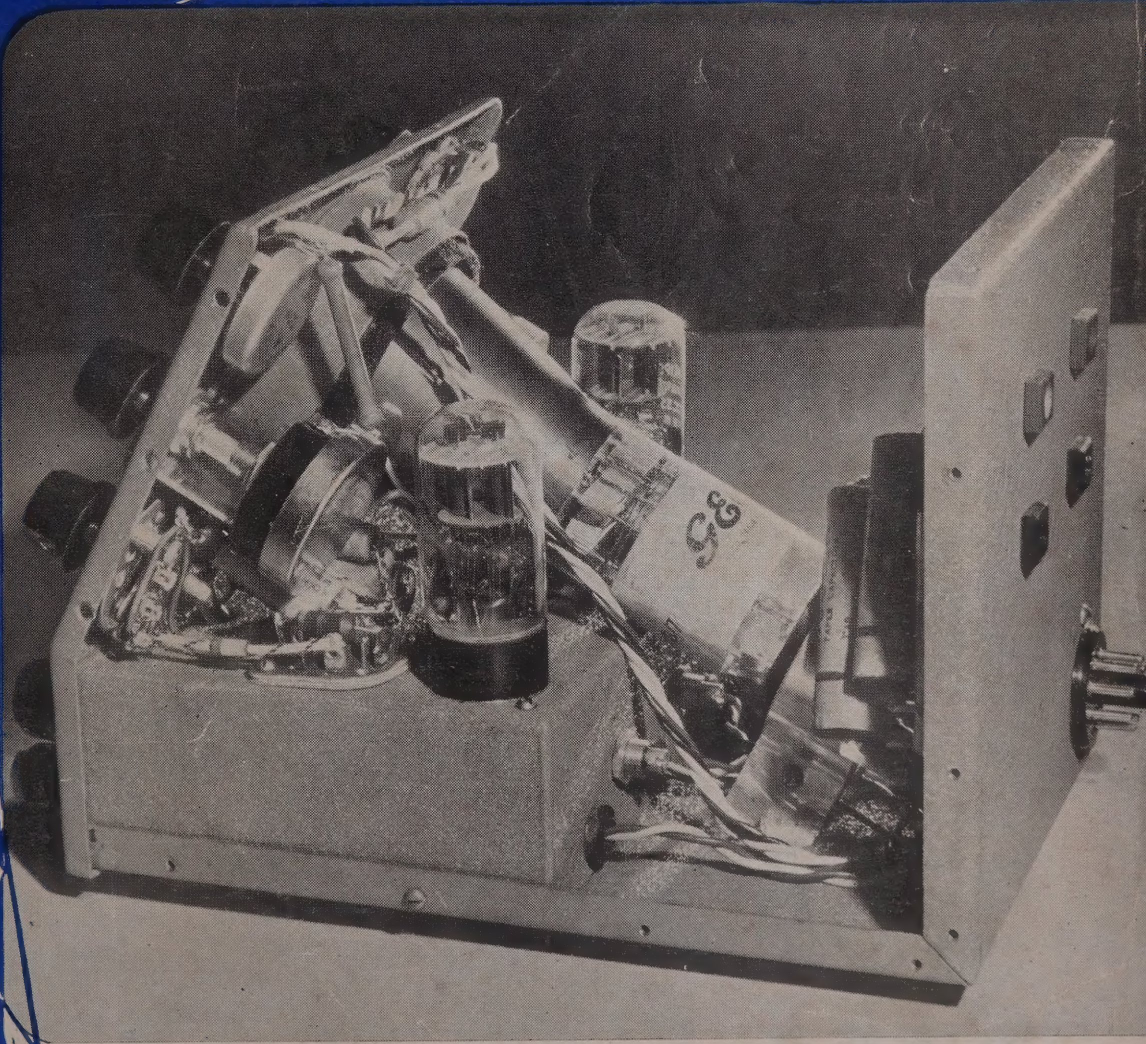
RADIO and ELECTRONICS

ELECTRICITY — COMMUNICATIONS — SERVICE — SOUND



AUGUST, 1st, 1950

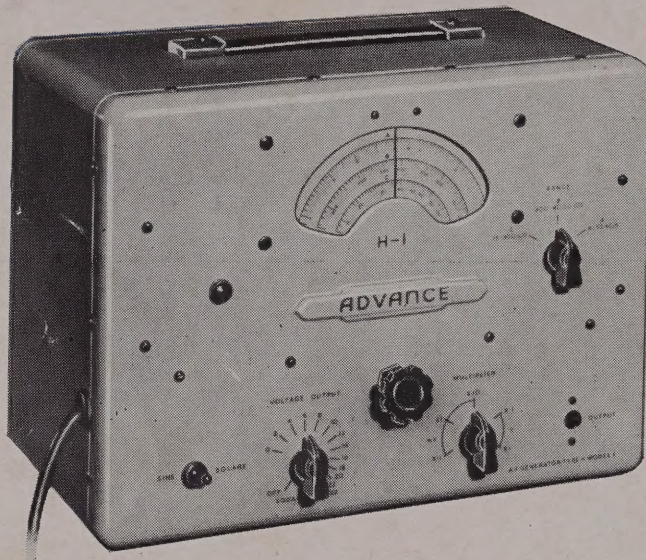
VOL. 5, NO. 6

1/10

Advance AUDIO and V.H.F. SIGNAL GENERATORS

TYPE H1 (Audio)

As Illustrated



FREQUENCY RANGE: 15 c/s. to 50,000 c/s. in 3 ranges.

CALIBRATION ACCURACY: ± 1% ± 1 c/s.

OUTPUT: From continuously variable and step potentiometers. Sine wave 200 μV. to 20 Volts ± 1 db. Square wave 400 μV. to 40 Volts, *i.e.*, 800 μV. to 80 Volts peak to peak.

DISTORTION: Less than 1 per cent. at 1,000 c/s.
RATE OF RISE OF SQUARE WAVE: Less than 3 μseconds to reach 90 per cent. of peak value at 10 kc/s.
POWER SUPPLY: 105–125 volts; 210–250 volts; 40-100 c/s. A.C. only. Power consumption, 30 watts approx.

DIMENSIONS: 13 in. x 10 in. x 8 in.

WEIGHT: 14 lb.

FINISH: The instrument is in an attractive steel case, the panel and case being sprayed with a durable cream enamel. A leather carrying handle is provided.

TYPE D1 (V.H.F.)

FREQUENCY RANGE: 9.8-310 Mc/s in 6 ranges.
CALIBRATION ACCURACY: ± 1%.
OUTPUT: 1 μV to 100 mV. Accuracy 10 Mc/s-150 Mc/s ± 2 db ± 1 μV. 150 Mc/s-310 Mc/s ± 2 db ± 2 μV.
OUTPUT IMPEDANCE: Unterminated line 75 ohms. Terminated line 37 ohms.
MODULATION: The carrier may be internally modulated at 30%, 1,000 c/s, or with 50/50 square wave where a minimum of frequency modulation is required.
R.F. LEAKAGE: Triple screening and careful filtering have made leakage negligible.
POWER SUPPLY: 210-230-250 volts, 40-100 c/s, and 80 volts 500-2,000 c/s, approximately 25 watts.
DIMENSIONS: 12¼ in. x 14¼ in. x 7¼ in. deep.
WEIGHT: 36 lb.

TYPE F1 (Audio)

FREQUENCY RANGE: 100 c/s.- 10,000 c/s.
CALIBRATION ACCURACY: 2% ± 25 c/s.
POWER OUTPUT: 1 watt level to ± 6 db over the full range.
OUTPUT IMPEDANCES: 600 ohms, 5 ohms, or 10 ohm attenuator.
DISTORTION: Less than 3% at 1,000 c/s at 1 watt into a 600-ohm load.
VOLTMETER: Range switched automatically with the impedance switch. Two ranges 0-40 and 0-4 volt.
POWER SUPPLY: 110-210-230-250 volts, 40-100 c/s, 40 watts.
DIMENSIONS: 13 in. x 10½ in. x 7¾ in. deep.
WEIGHT: 16 lb.

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RADIO and ELECTRONICS

Vol. 5, No. 6 August 1st, 1950

OUR COVER:

An internal view of the oscilloscope described in this and the previous issue of *Radio and Electronics.* Reference to this photograph is made in the text of the article commencing on page 13.

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A REALISTIC ATTITUDE TOWARDS TELEVISON

Several times since this journal made its first appearance we have written editorially on the subject of television. Up till now our chief concern has been to refute the oft-held beliefs that, in the first place, television would come to this country in a very short time, and, secondly, that, when it does come, it will in no sense even tend to oust ordinary sound broadcasting as a medium of home entertainment. Both the above statements we still hold to be facts, and nothing has occurred to alter our opinions on them. But events march, as the French might say, and we have recently been treated to the news that the plans in Australia for an experimental television station in about two years' time have been confirmed, with the important alteration by the new Government there that private firms may, if they wish, provide television service provided the technical standards which have already been decided upon are adhered to.

This brings the whole question rather nearer home as far as we are concerned, for in general we do not lag so very far behind that country in matters of development. Already here a committee has been set up to investigate the whole question, and ultimately to make a report, but considerable time has elapsed since the body started functioning, and, so far, no concrete results have accrued.

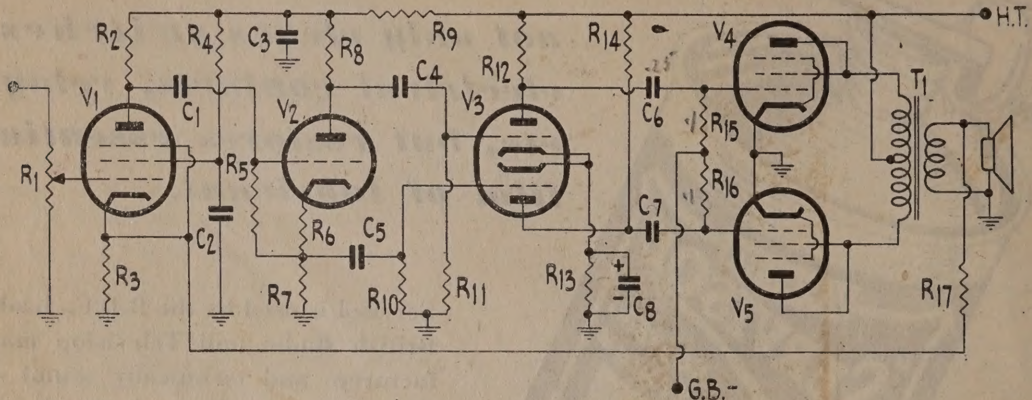
As far as the radio industry is concerned, there is only one thing to be decided, as a matter of policy—namely, would the early institution of a television service react favourably or unfavourably upon it? It appears to be one of those questions to which the only unassailable answer will come when we try it and see, but there is good reason to believe that, when television does come, and subject to the teething troubles that must arrive with it, it will on the whole be a good thing. At first, here as elsewhere, the volume of business to be derived from it will not be large, but will grow as the system develops. No one can say that television has even started to reach its final magnitude, either in Britain or in the U.S.A., but there is no gainsaying that in the latter country the television industry is already a very large one. Ultimately, then, we can expect it to open a large new field of endeavour for New Zealand's radio industry, and there is every reason to expect that the industry will be fully capable of rising to the occasion.

Apart from this, though, there must be some concern as to the possible effects of television on what is today the bread and butter of the radio industry—namely, the domestic radio-set market. At one stage, the wrongly-supposed imminence of television seemed to cause a recession in buying by the public, and we have it on good authority that in America the sales of domestic receivers did fall off to some extent *after* television actually arrived. This is perhaps natural, since it will take the public at large some time to find out for itself what those in the know have been telling them for some time about the independence of ordinary broadcasting and television broadcasting—that the two are complementary and not mutually exclusive. However, it appears that the arrestment of ordinary radio sales in the U.S.A. has already begun, in a big way, to correct itself, and that the broadcast-set market is rapidly getting back to normal.

The problem which confronts the industry in this country today is whether to let events take their course, or whether to do all in their power to bring television closer, and which course of action is taken by the industry depends upon the relative importance attached by it to the conflicting considerations set out above. It may be that the industry's best interests will be served by helping to start television as soon as possible, thereby resolving at the earliest possible moment the conflicting tendencies which must arise sooner or later. Even if the Government is to be urged to institute a service as soon as possible, and also to allow private enterprise to do something about it if it wishes, it is reasonably certain that it will still be a matter of years before anything very startling happens. This, however, should not deter the industry from taking whatever steps it may deem necessary in the meantime. One of the most difficult hurdles, when it does come, is going to be the provision of trained personnel. Today, even in America, they are suffering from a lack of skilled televisin servicemen and technicians. It appears, then, that for long-term planning, today is not too soon for the New Zealand industry to start thinking about what is to be done *now* if television should arrive within three or four years. We believe that at a very recent meeting of the Radio Manufacturers' Federation the above problems were actively discussed, as was the vexed question of apprenticeship in the radio industry. These are both important matters, the second being even more so than usual when the possibility of having to provide skilled television personnel within a relatively few years is taken into account. It will be of great interest to us and to our readers to learn, as we hope to do very shortly, just what the Federation has decided upon in these matters, and we would like to go on record as being of the opinion that by discussing them and endeavouring to get something done the Federation is taking up a commendable and realistic attitude. It is certain that if such problems are not discussed, the progress made will be nil.

A LOW-POWERED HIGH-QUALITY AMPLIFIER

THIS amplifier has been designed to fulfil all the requirements of a high-quality amplifier at relatively low first cost. The basic idea behind it is that by accepting a comparatively low output power, which is no disadvantage in many cases, one is able to achieve the important advantages of low distortion and wide frequency range at considerably less cost than when a power of 15 watts or so must be obtained.



COMPONENT LIST

R_1, 500k. pot.
R_2, R_7, R_8, R_{15}, R_{16}, 100k.
R_3, 1500 ohms.
R_4, 250k.
R_5, R_{10}, R_{11}, 500k.
R_6, 5k.
R_9, R_{12}, R_{14}, 50k.
R_{13}, 600 ohms.
R_{17}, see text.
C_1, C_4, C_5, 0.1 μf.
C_2, C_6, C_7, 0.25 μf.
C_3, 8μf, 450 electro.
C_8, 25 μf. 25v. electro.
T_1, output transformer, 5000 ohms (p–p) to voice coil.
V_1, EF37 or EF37A.
V_2, 6J5 or 6J5GT.
V_3, 6SN7-GT.
V_4, V_5, 6V6, 6V6-G, or 6V6-GT.
G.B.—, 20 volts.

INTRODUCTION

There must be a great many of our readers who, while enthusiastic enough about high-quality amplifiers to want to build one of the fairly ambitious circuits which have appeared in these pages from time to time, have been prevented from actually constructing one by the rather high cost of parts. If this is the case (and we think it highly probable that it is) then the amplifier we are about to describe will be a boon to numbers of them. This amplifier has been designed in such a way that from the point of view of frequency range, and low distortion, it is in no way inferior to any of the larger amplifiers that have been described in these pages over the last few years. For example, the only way in which it differs fundamentally from the "New High-quality Amplifier," published in the June, 1949, issue, is that the latter amplifier could produce up to 15 watts, according to the power supply used with it, while the present one will deliver only 4 watts maximum.

Before going on to see how this effects economies in building costs, it may be necessary to dispel some notions that a four-watt amplifier is of no real use for high-quality reproduction. It has very often been said, and written, that for really high-quality reproduction, one must have an amplifier of at least 15 to 20 watts output power, and because of this, many people have been put off, as we said before, by the estimated expense of the amplifier. There are any amount of quality enthusiasts who will swear that anything less than 20 watts (or 15 watts, or perhaps 10) is quite useless, however low the distortion, and however wide the frequency range. But don't believe a word of it! We would be the first to admit that 15 watts or so is desirable under many circumstances, and essential under others. In fact, our own high-quality amplifiers are rated at 20 and 15 watts respectively, but this does not alter the fact that four watts of high-quality output can be exceedingly useful under most conditions of use in the home. One of the few occasions when more power than this is really needed is when a volume expander is to be used, and the output has to fill a large room. The writer was for some years content with an amplifier with only 5 watts output, and now that he possesses an amplifier capable of 15 watts or so and a reasonably large living room which has to be filled with sound, he rarely finds it necessary or desirable to turn up the level to the point where the peak levels even approach the maximum capability of the amplifier.

It is true that a small amplifier is likely to be run closer to its maximum output power than a large one, and some years ago this would have meant putting up wtih more distortion, but the same is not true today. Before the advent of negative feedback amplifiers, there was considerable point in using an amplifier rated at, say 20 watts, at a maximum level of three or four watts. This was one way of reducing the distortion to quite a low figure, but it was an extremely expensive way of doing so, and one which need hardly be employed today. The reason is to be found in the fact that

modern feedback amplifiers can be constructed so that until the overload point is actually reached, the percentage distortion remains at an exceedingly low figure —so low, in fact, that only a few years ago it would not have been possible to measure it. As an example of what is meant, suppose our 4-watt amplifier gives less than 0.25 per cent. distortion at all outputs below the overload point. Then, at all levels within its capabilities the harmonic and intermodulation distortion is likely to be so low as to be negligible, and as long as the overload point is not reached in use, there will be no point in running the amplifier at low levels in an attempt to reduce distortion. The amplifier is then a much more economic proposition, since it is being used at its full capacity at all times without disadvantage.

To those who are experimentally inclined, and who have hitherto confined their amplifiers to medium or high-power outputs, we would recommend that a little time spent in duplicating the present circuit, and comparing it critically with a high-powered amplifier of similar quality will show that in practice, the high-power advocates do not have things all their own way by any means. At the same time, we would point out to those with comparatively slender resources that a high-quality amplifier of, say, four watts output *must* give better results than can a common or garden amplifier of similar power. Four to 4½ watts is reckoned sufficient volume from the average radio set, even when most of them give this output only with severe distortion, so that if the same maximum sound level can be provided, but improved immeasurably in quality, it stands to reason that except for special purposes, the results should be all that may be desired.

HOW ECONOMY IS EFFECTED

Having attempted, successfully, we hope, to "sell" the above idea to readers, we should perhaps try to explain how lowering the maximum power output does effect economy in the first cost of the amplifier.

There are two main reasons why a 4-watt amplifier will cost less to build than a 15-watt one. The first of these is the reduction in H.T. voltage and current. Here we have used a pair of 6V6s, connected as triodes, as the output tubes. The power required from the supply is only 24 watts, comprising 80 ma. at 300 volts. This is a very different thing from 400 to 450 volts (or even higher) at 120 to 150 ma. The price of power transformers starts to go up very rapidly after H.T. ratings of 100 ma. are passed, and if one can get enough power output with a 100 ma. transformer, the amplifier will cost considerably less. Remember, too, that the smoothing chokes also come into the picture, and that these are relatively cheap in sizes up to 100 ma., but rapidly increase in cost above this figure.

The other main expense attached to any resistance-caapcity-coupled amplifier is that of the output transformer. If the amplifier is to be rated at 15 or 20 watts, a very expensive output transformer is necessary, costing anything up to £10 all by itself. But if only 4 or 5 watts is to be handled, then a transformer of similar quality will cost only a fraction of this figure. We have thus made two major contributions towards reducing the initial cost without even considering the amplifier circuit itself! Actually speaking, there is not a great deal of economy to be brought about inside the amplifier proper—at least not in the present design, because we have set out to produce quality as nearly as possible equal to the best, which definitely precludes any cheese-paring as far as circuit components are concerned, or in reducing the number of valves to a minimum. However, for the small amplifier, it can be said that valve cost is likely to be smaller than for the large one, even if only because large valves like the EL37, KT66, or 6L6 are more expensive than are 6V6s.

THE CIRCUIT

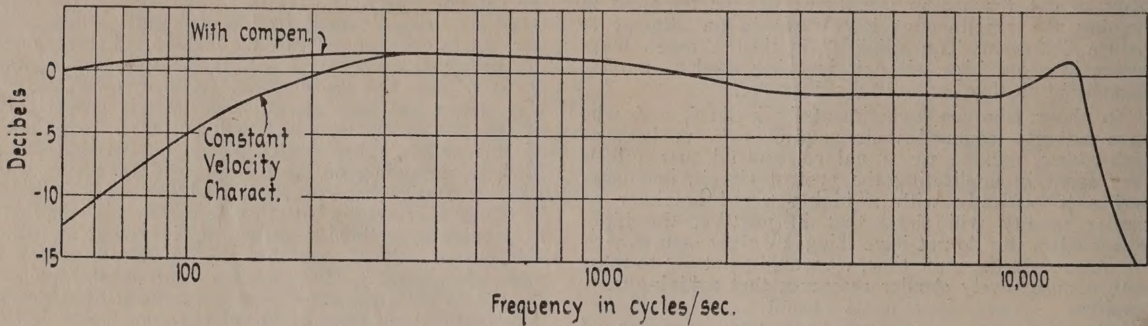
The circuit arrangement chosen for this amplifier is very similar to that of the previously-mentioned EL37 amplifier. The main difference is that the latter had a pair of cathode followers interposed between the push-pull driver stage and the grids of the output stage. Here the cathode followers have been omitted, and the output tubes are driven directly by the push-pull voltage amplifier, V_3. In order to increase the undistorted power output of the triode-connected 6V6s, these tubes are operated at fixed bias. On the diagram given herewith, no grid bias source has been shown, since this is properly part of the power supply, which will be detailed in Part II of this article. The correct voltage is between 20 and 22 volts, depending on the tubes (since these vary somewhat in static characteristics) and this can, if desired, be obtained from dry batteries. It is also a simple matter to provide a rectified negative supply giving an adjustable output voltage, and this will be described with the main power supply. However, for experimental purposes, the use of batteries saves a certain amount of temporary construction, and steps of 1½ volts are not too large to be manageable.

The phase inverter, V_2, uses a 6J5, which is the same electrically as one half of a 6SN7. Thus, if one has two 6SN7s on hand, there is no need to procure a 6J5, since one half of the 6SN7 can simply be left unconnected. The main voltage amplifier is an EF37, pentode-con-

(Continued on Page 45.)

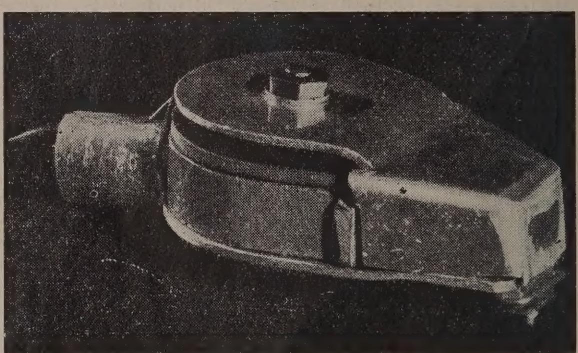
HIGH-FIDELITY PICK-UPS MADE AT HOME

IN Part I of this article, which appeared in last month's issue of *Radio and Electronics,* we described the construction of a high-quality pick-up, with excellent characteristics, but a very low output voltage. Such a pick-up clearly needs special treatment, in particular with regard to the elimination of hum pick-up, both by the pick-up itself and in the pre-amplifier, so that a separate article is called for.

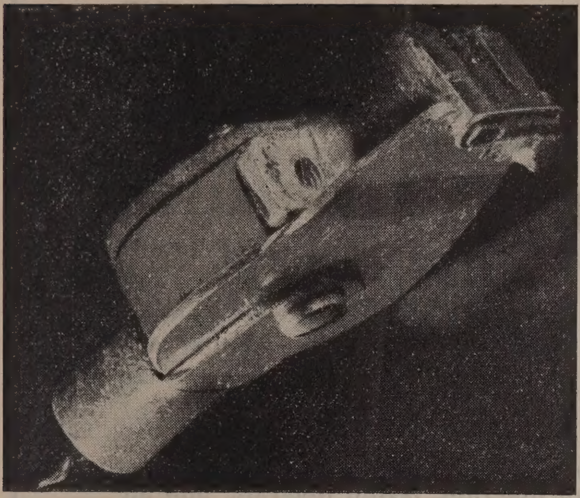


Response curves of the R. & E. *pick-up. The one labelled "Constant Velocity Characteristic" represents the performance that would be expected if the pick-up were used on a commercial record without bass compensation. The upper curve shows the overall response when used with the pre-amplifier whose circuit is given later in this article.*

Unfortunately, a few lines at the end of Part I were accidentally omitted from Page 48, rather leaving in the air the question of the correct way of inter-connecting the two pick-up coils. This omission had better be rectified first. It will be remembered that the last paragraph in Part I was headed "Wiring of the Two Coils." This was briefly described, after which came the unfinished sentence. This should read as follows: "In any case, it is easy to test whether the connections are correctly made by trying the pick-up, first with the connection one way, and then with the leads to one winding reversed. When the coils are connected in series opposing (the wrong way) the output will be very much smaller than when they are aiding, so that the right connection can easily be identified either by ear, or with the aid of an output meter or oscilloscope." It may be added that for anyone trying his hand at making pick-ups, a constant-frequency test record is a very good investment. It costs no more than any other red-label H.M.V. 12 in. record, and any dealer should be able to procure one from the wholesaler. The best one to buy is the H.M.V. ED 1189. This has a large number of small cuts, each being at constant amplitude, and of a particular frequency. The cuts range in frequency from 20,000 to 50 c/sec., and enable response curves to be drawn. The one appearing with this article was made from this particular test record. The constant frequency record is the best thing to use also for testing the output voltage in connection with the correct connection of the windings. Ideally, with the wrong connection, the output should be zero, but because it is virtually impossible to make two identical coils, one will have to be satisfied with noting that the wrong way round gives less output than the right way. In any case, the instructions given in Part I of this article will enable the correct way to be found without recourse to testing. The latter is useful, however, if one suspects that the coils were accidentally wound in opposite directions. Apart from the fact that the lower output itself makes the pick-up more susceptible to hum-pick-up, the correct connection of the windings gives quite a large measure of protection against hum. This is because a hum field passing through the windings produces theoretically equal and opposite voltages in them, which thus cancel out. We say theoretically, because since the coils will not in practice be identical, the hum cancellation will be imperfect. It is none the



View of the completed pick-up head. The top and bottom covers, made from 24-gauge aluminium sheet, are held in place by an $\frac{1}{8}$ in. Whitworth bolt. Note that a fibre plate, the shape of the magnet, is clamped by a nut, hidden in the photo, on top of the magnet. This can be seen in the photo on the next page. The top cover is spaced from the fibre plate by the hidden nut, so that this cover plays no part in holding the works together, its only function being to protect the pick-up from dust. Note how the bottom plate butts up against the back of the pole-pieces, preventing the rubber blocks holding the armature from slipping out backwards. Connecting leads are attached are mounted in the insulating fibre cover.



Another view, this time with the top cover removed. Note the wire clip near the bottom of the pole-pieces, and preventing the rubber blocks and armature from being pulled out in a forward direction. Also, in this view, the shaping of the front end of the bottom aluminium plate can be seen. The mounting plug is also made from sheet aluminium, and has a lug extending to the holding screw, which passes through it. It is possible to swivel the whole head sideways with respect to the mounting plug, so that any desired lateral offset angle can be provided.

less useful, and the direct hum pick-up is much less than would be found in a design with only one winding, which could not be arranged to buck the hum in any way at all.

A SUITABLE PRE-AMPLIFIER

As mentioned above, the output of the pick-up is rather less than one millivolt, so that a considerable degree of pre-amplification is needed for any ordinary amplifier. If the amplifier proper can fully load from a signal of 0.5 volts (a common figure) the pre-amplifier will need a gain of at least 500 times. This alone is considerably more than can be provided by a single valve, even a high-gain pentode, so that two stages will certainly be necessary. It should not be forgotten either, that since the pick-up has a flat velocity-operated characteristic, equalization will be needed, and this runs away with about 10 times gain. The pre-amplifier thus has to make up for this, too, which brings up the gain requirement to 5000 times. Luckily, this can still be provided easily by a two-stage amplifier, and a pentode, followed by a medium-gain triode, will fill the bill easily. In the case of the experimental pre-amplifier built to use with the pick-up, the pentode was an EF37, with a gain of 175 times, and this was followed by one half of an ECC35, with a gain of 45 times. The total valve gain was therefore 7900 times, which in practice was found sufficient. The loss in the equalizing network was almost 20 times, so that the overall gain was 7900 ÷ 10 = 790 times. The additional 1.6 times over and above the estimated requirement of 500 times is just enough to allow for contingencies, and cannot be regarded as excess gain.

The main difficulty of constructing a pre-amplifier with as much gain as this is that of reducing the hum level to an acceptable figure. One very necessary thing is to use valves especially designed for high-gain pre-amplifier work. These days, such valves are easy to come by, since the EF37 and EF37A (an improved version) are quite commonly available, and are no more expensive than ordinary receiving valves. They are specially constructed to have very low heater-cathode leakage, and low heater emission—two factors which make ordinary valves rather too susceptible to hum for special purposes like this. It is essential, too, to take great care with the wiring, so that the first grid circuit, in particular, forms no closed loops linking stray magnetic fields, thereby inducing hum into the grid circuit. One good thing is that the impedance of the pick-up winding is very low—only about 50 ohms, and this helps considerably in guarding against induction hum. It is essential, too, to have a single earth-point for the first stage, much as in an R.F. amplifier. Heaters must not have one side grounded, but must be centre-tapped, preferably by equal resistors or a low-resistance potentiometer, rather than through a centre-tapped heater winding. The best place to earth the heater centre-tap is at the single earth-point used for the first stage.

It is necessary to shield all the input wiring, including the leads from the pick-up, and also to enclose the whole pre-amplifier in a metal box in order to shield it from R.F. pick-up. High-gain pre-amplifiers are apt to act as detectors for the local broadcast stations, and for such stray radiations as the transmitters of taxis, and it is quite disconcerting to have a record interrupted by the not-too-euphonious voice of a taxi-driver, just round the corner, calling up base for instructions!

(Continued on Page 42.)

THE "RADIO AND ELECTRONICS" ABSTRACT SERVICE

ANTENNAE AND TRANSMISSION LINES

Built-in TV antenna. The complete design characteristics of a tunable built-in antenna are given which can be accommodated to the cabinet.

—*Radio and Television News* (U.S.A.), May, 1950, p. 59.

The fan-type TV antenna is described which maintains the good broadband performance of conical antennas yet provides better high-band gain characteristics.

—*Ibid*, p. 66.

AUDIO EQUIPMENT AND DESIGN

A legion of audio enthusiasts have stuck to triode amplifiers through thick and thin for the reason that "triodes sound better." Here is a design of a high efficiency triode amplifier.

—*Ibid*, p. 55.

CIRCUITS AND CIRCUIT ELEMENTS

There have been a number of attempts to make a single valve time-base for magnetic deflection, and a circuit is given of the transitron type with feedback between anode and the grid for linearizing.

—*Electronic Engineering* (Eng.), May, 1950, p. 177.

The electron multiplier tube, which is applied to the problem of measuring very small currents or the counting of single ions or electrons, is described with mathematical analysis.

—*Proceedings of the I.R.E.* (U.S.A.), April ,1950, p. 346.

Balanced rectifier modulators without transformers. Some simple rectifier modulators are described which give balance against carrier leak but avoid the use of transformers.

—*Electronic Engineering* (Eng.), April, 1950, p. 139.

A high-stability oscillator circuit which has been used extensively by the B.B.C. for some considerable time is discussed and analysed.

—*Wireless Engineer* (Eng.), April 1950, p. 105.

Impedance matching networks. A method is described of designing a four-terminal network whose image impedance at one pair of terminals is a constant resistance. This is useful where there is an impedance varying with frequency to be coupled to a constant resistance.—*Ibid*, p. 113.

ELECTRONIC DEVICES

A method is described of pin-pointing ultrasonic energy. Two watts of sound energy are concentrated into an extremely fine area to form records on sound sensitive paper without touching its surface. A magnetostriction oscillator is described.

—*Electronics* (U.S.A.), April, 1950, p. 84.

"Optar"—a new system of optical ranging. The photoelectric exploration of images formed by a lens reveals the location of objects over short ranges. The application of the device includes a wide range of optical controls with automatic camera focusing including infra-red "radar" and devices to guide the blind.

—*Ibid*, p. 102.

Potentials generated by the contraction of muscles and muscle fibres are recorded and studied with the aid of electromyograph and an attempt is made to interpret the records in terms of physical movement.

—*Electronics* (U.S.A.), April, 1950, p. 190.

The "dekatron" tubes have been designed for work in the field of counting and computing. The tubes have multi-electrodes and cold cathodes on the scale of ten basis.

—*Electronic Engineering*, (Eng.), May, 1950, p. 173.

The Stroboconn provides a rapid means of ascertaining the exact frequency of any pitch note and is especially adapted for tuning electronic musical instruments. The presence of harmonics is also indicated. The pitch is read from revolving stroboscopic cards and the degree of accuracy is 25 times greater than the human ear can detect.—*Ibid*, p. 178.

Radar displays for traffic control and instrument landing are illustrated. The picture can be used to assist the pilot in avoiding collision with other aircraft or can be a method of presenting traffic control instructions to the pilot.

—*Proceedings of the I.R.E.* (U.S.A.), April, 1950, p. 391.

A simple electronic metronome is described with complete schematic diagram and parts list.

—*Radio and Television News*, (U.S.A.), May, p. 45.

MATERIALS AND SUBSIDIARY TECHNIQUES

Synthetic crystals possess characteristics that compare favourably with quartz. The paper presents recent developments and techniques.

—*Electronics*, (U.S.A.), April, 1950.

A new type of secondary emission valve is described which provides a wideband amplifier for decimeter waves.

—*Wireless Engineer*, (Eng.), May, 1950, p. 137.

The fabrication of ceramics is developing to the formation of plates for condensers having thickness comparable to that of paper and mica which holds promise for greatly improved condensers for certain purposes.

Electronic Engineering (Eng.), April, 1950.

A review is given of some of the most important facts and conceptions of piezo-electricity.

Philips' Technical Review (Holland), Nov. 1949, p. 145.

A symposium of papers on ferromagnetic materials—eddy current anomalies—losses in electric sheet metal—structural factors affecting the properties of soft magnetic materials—ferromagnetic cores at very low inductions—magnetization characteristics of nickel irons—incremental magnetic properties of silicon-iron alloys—power loss at audio frequencies—testing of transformer steels—magnetic powders and cores and discussions on ferrites.

Proceedings of the I.R.E. (Eng.), April, 1950, p. 119 *et seq.*

MATHEMATICS

Bass and treble attenuation or accentuation of two types of R-C equalizers for audio frequency circuits are easily determined from the graph supplied. This should be extremely useful for those designing such circuits.

—*Electronics*, (U.S.A.), April, 1950.

A brief study is made of a phase amplitude theorem to the design of feedback amplifiers with constant phase margins.

—*Proceedings of the I.E.E.*, Part III, May, 1950, p. 138.

A study of electrostatic field problems. The stretched elastic threads so often used as analogies are liable to be carried too far and may lead to a misconception of the electrical field.

—*Wireless Engineer* (Eng.), May, 1950, p. 135.

A simple theory of travelling-wave tube gain. A typical tube is described and its functioning.

—*Bell System Technical Journal* (U.S.A.), Jan., 1950, p. 3.

A perennial problem is that of designing a circuit to split a signal into two parts which differ in phase by a constant amount. Methods are here described.—*Ibid*, p. 94.

MEASUREMENTS AND TEST GEAR

The application of electronics to measurement and testing has widened the range of useful measurement. A survey is made of the field and the electronic instruments used.

—*Electronic Engineering* (Eng.), May, 1950.

A simple method of determining impedance and admittance values over ranges of frequency from 1,000 c/s. to 150 k.c. is described.

—*Wireless Engineer* (Eng.), May, 1950, p. 154.

The "Genescope" is a TV test instrument with comprehensive circuitry for the testing of television sets.

—*Radio and Television News*, (U.S.A.), May, 1950, p. 60.

MICROWAVE TECHNIQUES

Licrowave lenses. A series of articles are presented dealing with the optics of lenses, theory, and construction.

—*Electronic Engineer* (Eng.), April, 1950, p. 127 and May 1950, p. 183.

The difficulties of comprehending wave phenomena occurring in wave-guides is simplified by the use of models with vibrating membranes. Both for the student and the designer the system has much to commend it.

—*Philips Technical Review* (Holland), Nov., 1949.

PROPAGATION

The newer systems of modulation, such as F.M., pulse position modulation, and pulse code modulation have the property that it is possible to exchange bandwidth for signal to noise ratio. Here is a non-mathematical examination of communication theory.

—*Electronics* (U.S.A.), April, 1950, p. 80.

A description is given of an eight-channel multiplex modulation system wherein the pulses of the various channels are interwoven and demodulated.

Philips Technical Review (Holland), Nov., 1949, p. 133.

TRANSMITTERS AND TRANSMITTING

In accordance with the Copenhagen Wavelength Plan, the B.B.C. changed the wavelengths of nearly all its programmes on March 15. A schedule of the new wavelengths for the English stations is given.

—*Electronic Engineering*, (Eng.), April, 1950, p. 161.

A supermodulated phone transmitter is described which uses the Taylor modulation system, is very small, and capable of handling as high as 90 watts of power input.—*Ibid*, p. 51.

TELEVISION

A new method of synchronization is described to avoid the effects of noise on a television picture in the so-called fringe-areas. The principle used is to use a selective amplifier to extract the fundamental frequency component from a separated synch. waveform and to use this with a flywheel circuit.

—*Electronic Engineering* (Eng.), April, 1950, p. 149.

One of the problems to be overcome in a vision receiver is that of sound break through. The use of the "Bridged-Tee" filter to prevent this is described.—*Ibid*, p. 155.

Deflector coil characteristics Part 2. The dimensions and methods of windings of the coils are given.

—*Wireless World* (Eng.), April, 1950, p. 147.

MISCELLANEOUS

Radar Echoes from Meteorological Precipitation—rain-drops, snowflakes, and hailstones. The facts have been utilized for the development of light-weight radar sets to warn pilots of meteorological hazards.

Proceedings of the I.E.E. (Eng.), Part I, May, 1950, p. 89.

A short biography of Oliver Heaviside, born on May 18, 1850, and some facts about his work.

—*Electronic Engineering* (Eng.), May, 1950, p. 188.

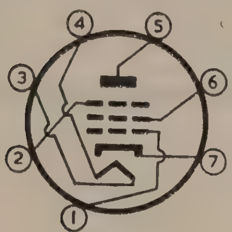
A method is given of home anodizing your panels in colour. It is stated to be perfectly possible for any amateur to produce panels with a jewel-hard surface in any colour he desires. Here's a pretty pickle.

—*QST* (U.S.A.), May, 1950, p. 54.

TUBE DATA: Grounded-Plate Type 6AU6 Triode Connection For Pre-Amplifier Use

This information is reprinted from Radiotronics, *through the courtesy of Messrs. A.W.V. Co. Ltd.*

Difficulty is usually experienced in reducing to satisfactory low levels the hum and noise from the input stage of a high gain A.F. amplifier. If for example noise is required to be 60 db. below full output in an amplifier which is fully driven by a 5 millivolt input signal, then the noise and hum voltage at the grid of the first valve must be 5 microvolts or less.



Pin 1 Grid No. 1.
Pin 2 Grid No. 3.
Pin 3 Heater.
Pin 4 Heater.
Pin 5 Plate.
Pin 6 Grid No. 2.
Pin 7 Cathode

Fig. 1.—Type 6AU6 base connections.

In valves having the grid brought out to a top cap, the hum voltage induced electromagnetically from stray magnetic fields into the loop of wiring between grid and cathode of the valve may be excessive, and with double-ended valves it is not easy to reduce the area of this loop sufficiently. Further, electrostatic shielding of the grid circuit components and leads, and of the grid cap itself, is also necessary, but is difficult to achieve satisfactorily with this type of valve construction.

Single-ended valves minimize these troubles, but introduce a new one. The proximity of the grid, heater and plate contacts on the valve socket make for severe leakage and capacitance requirements of the valve base and socket. Thus, if leakage were the only consideration the insulation resistance between control grid and heater pins, in order to realize the above noise level, would need to be of the order of 50,000 megohms if the grid circuit impedance were 0.1 megohm.

However, by using the guard ring principle satisfactory attenuation can be achieved more readily, and if, for instance, earthed contacts and the earthed centre spigot can be arranged to isolate the heater contacts from the grid and plate contacts, then hum problems due to leakage are greatly minimized. It is assumed in such cases that neither side of the heater winding is earthed, as centre tapping is usually necessary to reduce the hum level to a minimum.

Figure 1 shows, that with the triode connection mentioned in Radiotronics No. 139 (grid Nos. 2 and 3, plate and shield connected together), there is no low impedance connection to ground between grid 1 and heater, so that hum trouble in the grid circuit is possible. By earthing pin 2 (the suppressor) this trouble may be overcome, but under the recommended triode operating conditions, this leads to the maximum rating for the screen dissipation being exceeded in some valves. In addition, with pin 2 earthed, the leakage from heater pins to 5 and 6 (triode plate) is unbalanced and will be troublesome at low signal levels. Leakage in the 6AU6 itself will not be serious because its base material is glass, and in this respect it is an improvement over previous types of moulded bakelite bases (particularly single-ended types), but the insulation requirements for the socket will still be severe.

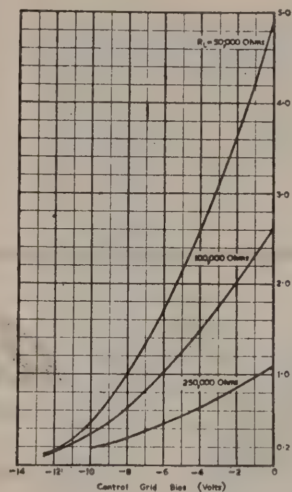


Fig. 2

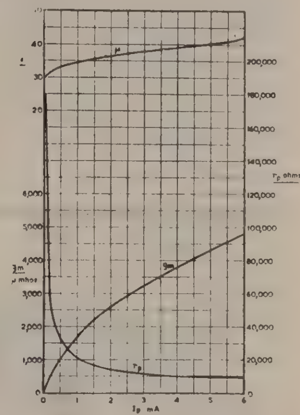


Fig. 4

A recommended method of operating the 6AU6 as a pre-amplifier to overcome these troubles is to use grid 2 as the triode plate, with grid 3, the pentode plate and

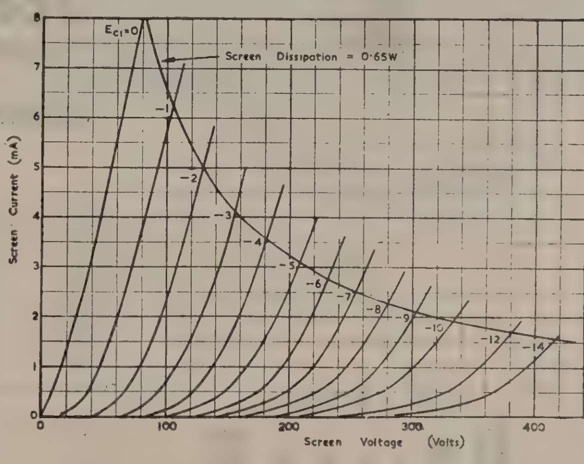


Fig. 3.—Curves of 6AU6 screen current vs. screen voltage for fixed values of grid No. 1 bias ($E_p = E_{c3} = 0$).

the external shield grounded. This gives an earthed contact on either side of the heater pins and the plate contact, while the grid has an earthed contact on one side and the cathode on the other.

Triode connection is desirable for a pre-amplifier because triodes are inherently less noisy than pentodes, firstly because of their higher $g_m/\sqrt{I_b}$ ratio and secondly because there is no noise due to random division of current between plate and screen.

The linearity of the mutual characteristic of grid 2 used as the plate is good, as indicated in Fig 2, in which

the dynamic characteristic for three different resistive plate loads is shown.

There are, however, two disadvantages of this method of connection. Firstly, the screen grid dissipation must not exceed 0.65 watt, which may restrict a transformer or choke-coupled design, and secondly, at higher output levels distortion is higher than with the standard triode connection. This grounded-plate connection is accordingly recommended only for low level pre-amplifier use.

Figure 3 gives the plate characteristic of the 6AU6 operated in this manner, and Figure 4 shows μ, g_m, and r_p as a function of plate current.

Some typical operating conditions are set out below.

TYPICAL CONDITIONS

E_{bb} = 300V.			
R_L (megohms)	0.05	0.1	0.25
R_K (ohms)	230	450	1,000
I_b (mA)	4.3	2.35	1.0
Stage gain*	25	25	23
E_{bb} = 180V.			
R_L (megohms)	0.05	0.1	0.25
R_K (ohms)	450	750	1,600
I_b (mA)	2.4	1.3	0.59
Stage gain*	21	23	21
E_{bb} = 90V.			
R_L (megohms)	0.05	0.1	0.25
R_K (ohms)	1,100	2,000	4,000
I_b (mA)	0.93	0.54	0.25
Stage gain*	14	14	13

*Resistance of following grid leak = 0.5 megohm.

An Easily Built 3 in. Oscilloscope For General Purpose Use

PART II
AN APOLOGY

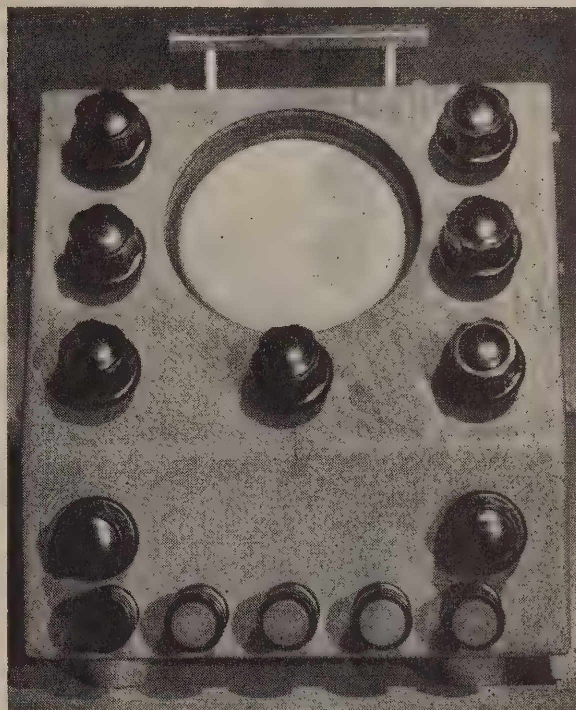
Before we complete the description of the oscilloscope there is unfortunately an apology that must be made. When, a few weeks ago, the oscilloscope was designed, there was every reason to believe that stocks of the required cathode ray tubes would continue to be available, as they had been for some considerable time. Only the other day, however, and quite by accident, we discovered that the agents for the tubes concerned had disposed of existing stocks, and signified their intention not to import further supplies of cathode ray tubes. This is most unfortunate, as we have always made it our business, wherever possible, to use equipment that is generally available in this country. However, the situation is not as bad as it might be, because the tube concerned was made in England during the war in very large quantities by a number of different manufacturers. We have it on good authority that before very long, tubes will be available which, if not exactly equivalent, will be able to replace the E-4102 in our circuit, in all probability without any alterations of values. We will keep an eye on the situation, and when suitable tubes become available, readers will be advised through these pages, and any circuit alterations that may be necessary will be indicated.

CONTINUATION OF CIRCUIT DESCRIPTION

At the end of Part I of this article, we were describing the action of the amplifier stages under the influence of a mixed D.C. and A.C. input signal, consisting of the shift voltage and the waveform to be examined, in the case of the Y amplifier. Any distortion, it was stated, occurs only after the deflection of the spot has carried it off the screen of the C.R.T., and so does not matter in practice. The reason for this convenient behaviour is that the valve is unable to distinguish between alternating and direct grid voltages, so that as long as it can produce more than enough undistorted output voltage to fill the screen, any distortion due to the differential biasing arrangement which constitutes the shift control cannot affect the waveform of that part of the signal which lies within the linear portion of the valves' characteristics.

In the more ordinary circuit that is almost always used for supplying E.H.T. voltage for cathode ray tubes, the final anode is grounded, so that when the deflecting plates are connected to the amplifier valves' plates by condensers, and leak resistors are provided from the deflecting plates to ground, the deflecting plates reside at the *average* potential of the final anode, namely, earth potential.

With direct amplifier coupling, on the other hand, the deflecting plates are placed at a D.C. potential equal to that of the amplifier valve plates. This potential is usually of the order of +300v., so that if de-focusing of the spot is to be avoided, the final anode must also be returned to a potential of +300 volts. This has the added advantage, aforementioned, that this 300 volts is added to the effective H.T. voltage across the cathode ray tube. When direct coupling is used, therefore, it is necessary to find some method of returning the final anode to the same potential as the amplifier valve plates. Hitherto, the method used has been to place a voltage divider across the positive H.T. supply, with a potentiometer in the appropriate place to allow the moving arm to be adjusted to the required potential. This makes another pre-set

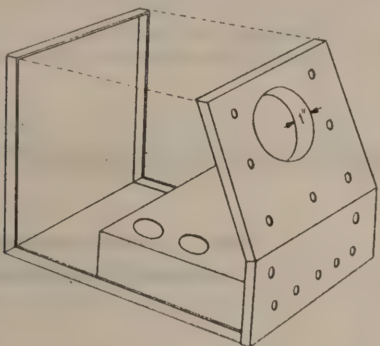


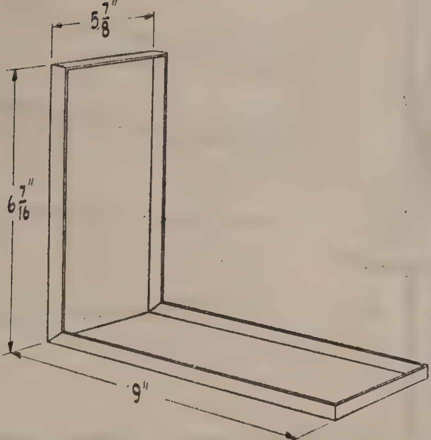
Front view of the 'scope showing the controls. These are as follows—Left hand row, top to bottom: Brilliance, Y-shift, Synch., Y gain. Right-hand row, top to bottom: Focus, X-shift, Coarse Freq., X gain. The centre control under the tube is the Fine Freq. The terminals, from left to right, are: Earth, Y-Input, Time-base Output, X-Input, Earth.

adjustment, however, and this is liable to require readjusting if and when amplifier valves are changed. Some automatic method would be preferable, if it could be devised, and in the course of our experimental work we hit on a solution that is, as far as is known, original, and yet exceedingly simple. Between the plates of the Y amplifier valve, two high-value resistors are connected, and the final anode of the cathode ray tube is connected to their junction. In theory, this scheme should work perfectly, because the signal voltages at the plates of the valves are equal in amplitude, and exactly out of phase, so that at the junction of the resistors the signal voltage should be zero. At the same time, the D.C. voltages at the amplifier plates are either equal or symmetrically positive and negative with respect to their common voltage when no shift is applied. Thus the potential at the junction of the resistors is at all times equal to the average potential of the deflecting plates. In practice, this scheme was found to work exceedingly well, and although it was half expected that there might be some untoward effects due perhaps to cross-talk between the two amplifiers, X and Y, such disadvantages were found to be completely absent.

Both amplifiers have been made identical. This is an important point, particularly for observations and measurements in which the linear time-base is not wanted. For example, where the amplifiers are to be used and phase comparisons are wanted, then identical X and Y amplifiers are of assistance, because their own phase shifts are almost identical.

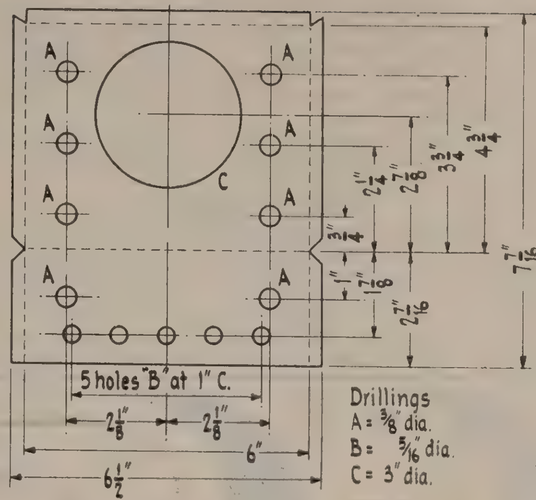
The time-base circuit is one that represents a considerable advance on most single-valve circuits. It looks rather like a transitron, but differs in that the charging condenser is connected between plate and grid as in the Miller integrator circuit. This circuit is notable for the ease with which it works. Unlike the transitron, it is not critical as to the exact valve characteristics, and it will not be found that circuit values have to be experimented

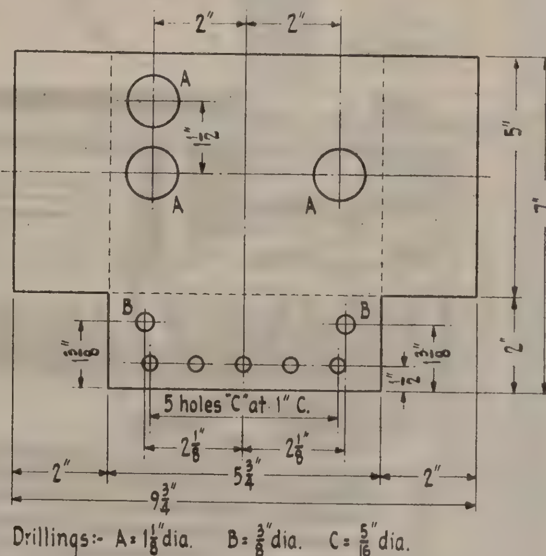




General arrangement view, and working drawings for chassis work. Note that the view of the chassis is a bottom one, i.e., the sides should be bent TOWARDS the viewer.

with in order to make it oscillate. It is also very sensitive to synch. voltages applied, as shown, to the suppressor. An input of only 20 millivolts or so is enough to give excellent synchronization. At the same time, quite large synch. voltages can be applied to the circuit without folding up the picture. It will lock at sub-multiples of the work frequency very far removed from it, and it would be a simple matter to arrange for automatic synchronization by making the synch. control pre-set, but for the utmost flexibility it is perhaps best to keep the control on the front panel, although it will require remarkably little adjustment, so positive is the synchronization.





One feature of the time-base is that the flyback time on any one range is approximately constant. As a result, the ratio of forward stroke to flyback time is slightly better at the low frequency ends of the bands than the high. However, since provision is made for blacking out the flyback, this does not matter very much at all.

BUILDING THE 'SCOPE IN TWO UNITS

For the sake of completeness, the full circuit has been given in Part I. It is however, a simple matter to segregate the power supply from the rest of the circuit. The only components that need to be in the power supply unit are the power transformer, the two 6X5 rectifiers, the two smoothing filters. The voltage divider for the C.R.T. cathode, grid and first anode should remain in the tube unit, because there will then be much fewer leads to be taken between the two chassis. The necessary leads are: (1) Earth; (2) 6.3v. for the heaters of the ECC35's and the 6AC7; (3) 4v. for the C.R.T. heater (the dropping resistor should be in the power supply chassis); (4)

H.T.+; (5) E.H.T.—. These make up only seven leads, so that an ordinary octal plug and socket may be used for inter-connecting the units. It is important, though, to see that the male portion is attached NOT to the power supply, but to the 'scope unit. This avoids all possibility of shock from the plug.

The portion of the circuit inside the dotted line on the diagram shows just what parts were included in the power supply unit in the original instrument.

CONSTRUCTION

Full working drawings have been made for the chassis and case of the C.R.T. unit, and are printed here for readers' convenience. These, and the two photographs give a very good idea of the construction. All controls except the balancing potentiometers for the paraphase amplifiers are mounted on the front panel, and can be identified from the photograph and its caption. The panel is held to the small chassis by means of the terminals and potentiometers mounted on the vertical lower portion. When the wiring has been completed, the chassis and panel are placed on the front of the tray which comprises the bottom and back of the box; it is held in place by two self-tapping screws, one at each side, passing through the flanges of the tray, into the sides of the chassis. These are enough to hold the two together until the box is completed by slipping on the cover, which makes up the top and sides of the box. Self-tapping screws are then inserted at intervals all round the flanges, holding the whole thing firmly together. It will be noted that the front panel and the back and bottom are made in such a way that the cover goes *inside* the flange of the front panel, but *outside*

(Continued on Page 33.)

RADIO IN CIVIL AVIATION

(Continued from Previous Issue)

By W. S. JOYNER, A.M.I.E.E., A.M.N.Z.I.E.

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(I) INTRODUCTION

This is the third article of this series. The first outlined the historical background of radio for aviation up to and during the war, and outlined the development of the International Civil Aviation Organization (I.C.A.O.). It will be recalled that I.C.A.O. laid down four broad functional classifications of radio aids to civil aviation.

(i) Short distance aid to navigation, *i.e.,* up to 200 miles.
(ii) Long distance aid to navigation, *i.e.,* 200 to 1,500 miles.
(iii) Aids to blind landing.
(iv) Aids to air traffic control.

The second article reviewed the modern situation relating to short distance aids and gave technical details of some systems.

The present article will cover the long distance and blind landing aids.

(II) LONG DISTANCE AIDS—GENERAL

The operational requirements for long distance work are quite different from those of short distance. In short distance aids the highest possible accuracy is a major requirement, in long distance it is relegated to about the lowest of the main requirements. It has been generally agreed that, by a review of ocean and general worldwide routes and consideration of radio propagation characteristics the range of a long range system should be of the order of 1,000 miles. If one world-wide system were adopted and the ground stations planned by international agreement, then about all air routes in the world could be covered from "reasonable" sites although some installations would be on remote islands. The fundamental requirements for such a system are, therefore:

(i) Good, reliable coverage up to 1,500 miles.
(ii) Simplicity of operation.
(iii) Reasonable site requirements for ground stations.
(iv) Reasonable accuracy.

During the war the American hyperbolic system Loran obtained its long coverage by utilizing the frequency band around 2 mc/s and training operators to distinguish the ground wave pulse from the ionospherically reflected ones. The airborne equipment, however, is very heavy, large, and requires considerable skill in operation while the ground stations are complex and have rather stringent siting requirements due to the normal necessity of any hyperbolic system to lock master and slave stations.

In order to obtain reasonable coverage during the full 24 hours it is also necessary to transfer the frequency down to about 200 kilocycles, but being a pulsed system the spread of modulation frequencies is completely unacceptable to the international allocation of medium frequencies for all the various types of user requirements. Again, good reception at M/F can be achieved only by very narrow band-widths to cut down noise level, but that is in direct conflict with the requirements of a pulse system.

The war time Loran chains have been mostly kept in service, and even extended, but, while no agreement has been finally reached as to the international standard aid, it is now generally agreed that Loran will slowly decline from its war-time status.

The most generally recognized alternative is a modernized form of a German system, by them called "Sonne," but now known as Consol, and since Loran in any case is likely to be well known to most readers this section will be devoted to a reasonably detailed description of the Consol system.

(III) CONSOL

The Consol navigational aid consists of a special medium frequency transmitter radiating from an aerial array of three mast radiators in line. The masts are spaced so that a multilobe radiation pattern is produced, which is swung slowly by progressive changes in the phases of the outer-aerial currents. Alternate lobes are

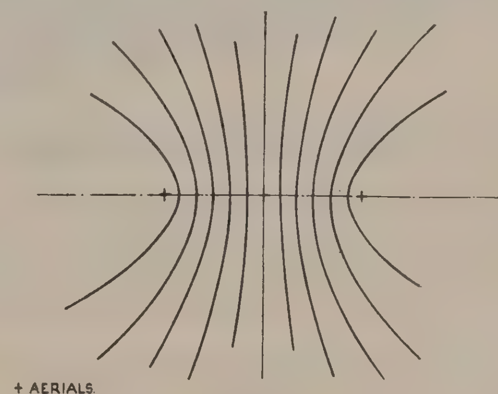


FIG. 1.

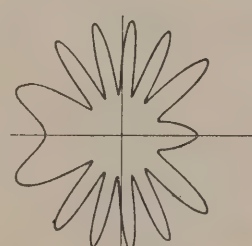


FIG. 2A.

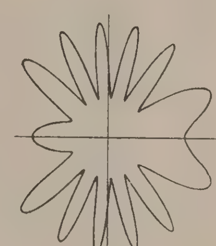


FIG. 2B.

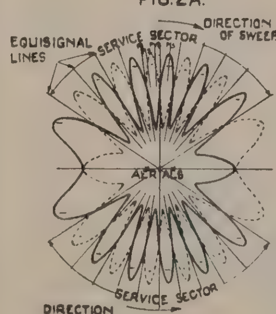


FIG. 3.

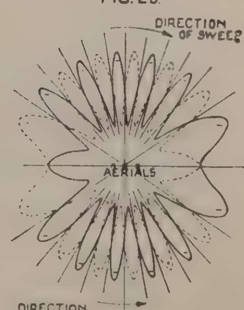


FIG. 4.

characterized by dots and dashes, which are interlocked so that on the boundary line between two lobes a steady tone is heard.

An observer within the range of the transmitter will hear a number of dots and dashes, a count of which determines his bearing from the transmitter within one of several sectors, which are between 10° and 15° in width. The observer determines which of these sectors he is in either from an approximate bearing of the station taken with an ordinary D/F loop.

The three aerials are spaced several wavelengths apart, giving a multi-lobe radiation pattern. If all three are fed in phase, there are lines of maximum field strength where the path lengths from the three aerials are equal or differ by an integral number of wavelengths; these lines form a hyperbolic pattern of the form shown in Fig. 1.

If the phase of the radiation from one outer aerial is now advanced by 90°, and that of the other retarded by 90°, the lines of maximum field strength will be displaced to one side (shown in Fig. 2A, as lobes of radiation). If however, these phases were respectively retarded and advanced, by a similar amount the maximum would be displaced in the opposite direction (Fig. 2B). These two radiation patterns are mirror images of each other. Now suppose that, by means of a phase-keying unit, the outer aerial phases are repeatedly reversed, so that these two patterns are radiated alternately; and to identify the patterns a dot-dash form of keying is used, so that one pattern is radiated for a relatively brief instant, and the other for (say) five times as long: then the resulting field-strength pattern is shown in Fig 3, one dot-dash cycle taking half a second. An observer at P_1 will hear a continuous tone (the "equisignal") since the dots and dashes are interlocked; an observer at P_2 will hear dots standing out from a background tone, and an observer at P_3 dashes over a background tone.

A beacon radiating a pattern such as this would be a multi-track range, in that an observer could home on the station along any equisignal line by adjusting his course to maintain a constant steady tone in the telephones. It would not, however, give any precise information to an observer located between two equisignal lines, apart from telling him that he was somewhere in a dot or a dash sector.

In order that a bearing may be obtained from any position (say P_2 or P_3 in Fig. 3), a phase-shifting circuit is introduced into the transmitter whereby the whole pattern of Fig. 3 is in effect swung slowly, as shown by the arrows, over a period of 30 seconds. Starting with the aerial-current phases as shown by solid lines in Fig. 6A, and assuming for the moment that the dot-dash phase keying is stopped, the phases of the outer aerial currently A and B are slowly shifted in opposite directions (Fig. 6B, solid lines) through 180°, until their phases are interchanged (Fig 6C, solid lines); at the end of this 30-second period the dot and dash sectors have been interchanged (Fig. 4).

When the dot-dash phase keying is superimposed on this slow phase-shift, the solid line sectors A and B in Fig. 6 are repeatedly reversed in phase, in the manner already described so that the A-aerial current vector (for example) alternates between the solid line positions A and the picked-line positions A_1 rotating slowly meanwhile in a clockwise direction. The B aerial vector behaves similarly, rotating slowly anti-clockwise. The dot-dash phase keying produces the radiation pattern, with its dot and dash sectors, while the slow phase-shift swings the pattern in the manner required.

The method of operation of the beacon can now be

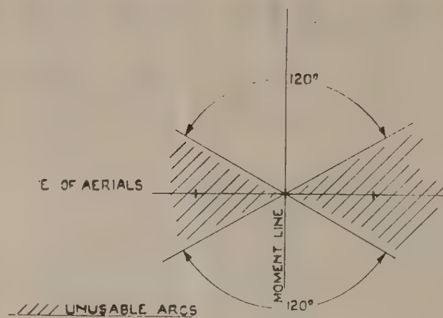


FIG 5

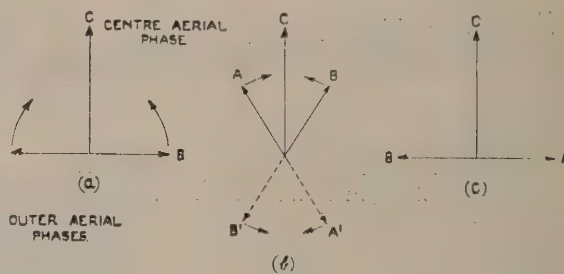


FIG. 6.

seen. Referring again to Fig. 3, and considering the observer at P_2, at the start of the 30-second keying cycle he will hear dots; as the pattern swings, the dots will become weaker and the background tone stronger until a steady tone—the equisignal—is heard, after which dashes emerge over the background tone, and continue to the end of the cycle. This observer will hear perhaps 20 dots before the equisignal, and 40 dashes after it;

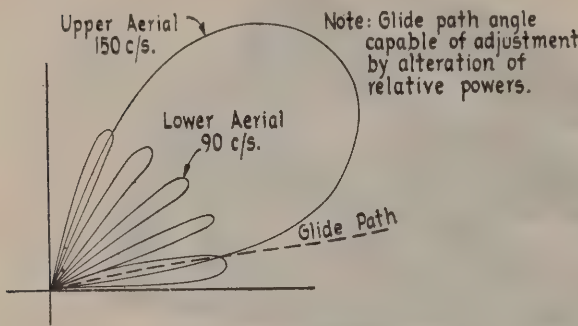


Fig. 7

another observer at P_4, further to the right, may hear 45 dots, followed by the equisignal and 15 dashes. An observer at P_5 will hear say 30 dashes before the equisignal, and 30 dots after it. Evidently, the number of dots or dashes heard before the equisignal determines the bearing of the observer within the sector X.

There remains a certain ambiguity in the results obtained, since the pattern radiated in the sector X is repeated in sectors Y and Z. The width of these sectors is, however, always well in excess of 20° (usually nearer to 30°), so that the ambiguity should always be resolved by the dead-reckoning position of the observer. An extraordinarily large error in navigation would be required for there to be any doubt which sector the aircraft or ship was in. However, as a second safeguard, a bearing can be taken on the station, by an ordinary D/F loop; after each 30-second keying cycle, the station call sign is transmitted and this signal can be used to obtain the check-bearing. An accuracy of ± 10° is sufficient to establish without doubt which sector the observer is in.

As stated above the standard Consol station consists of 3 mast radiators spaced several wavelengths apart. At 1,000 metres, this entails a separation between masts of 1.8 miles approximately and the propagation factors at this frequency require large earth mats of up to 200 metres in good earthing conditions, or up to 500 metres in poor earths.

(IV) AIDS TO BLIND LANDING—GENERAL

Having dealt with short-range aids in Article II, and long-range aids above, we now pass to the third I.C.A.O. classification—aids to blind landing. Even the L/F radio range beams, particularly with fan markers to indicate the passing over of a particular point, can be so sited as to provide sufficiently accurate guidance to enable aircraft to accomplish a "let-down" through cloud to visual conditions for the final approach and landing. The three stages of let down, approach, and landing each require a more intensive degree of accuracy in ascending order. Apart from occasional experimental and developmental attempts it is firmly recognized that no electronic or radio equipment can yet provide full blind landing and despite the fact that the I.C.A.O. system is called I.L.S. as an abbreviation for Instrument Landing System it is really an instrument *approach* system and a minimum ceiling of a few hundred feet is still demanded according to the general operational considerations of the particular aerodrome.

(V) I.C.A.O. INSTRUMENT LANDING SYSTEM

The I.C.A.O. system approved for installation on all international air routes is a slightly modified version of the U.S. Army Air Corps S.C.S.51.

It consists of a "localizer" which provides a sharp horizontal beam along which are placed three 75 mc/s fan markers to give distance indication, and a "glide path" which provides a beam in the vertical plane elevated at any preset angle from 2° to 5°. The basic principle of the localizer is the same as the L/F radio ranges, *i.e.*, the overlapping of two radiations on the same radio frequency but in the V.H.F. band. In this system one radiation is continuously tone modulated at 90 cycles the other at 150 cycles. By means of audio filters the two signals are separated and compared against each other by a centre zero meter. The glide path is somewhat similarly provided by overlapping radiations produced from the comparison of the reception of signals received from aerials at different heights from the ground. The two modulation characteristics are the same as for the localizer, *i.e.*, 90 cycles and 150 cycles and the radio frequency is of the order of 300 mc/s. This glide path is best explained by reference to Fig. 7. The vertical polar diagrams of the aerial systems indicates how the equisignal path is obtained; although the equisignal paths can be repeated the difference in angle is so great that no confusion arises.

(VI) GROUND CONTROLLED APPROACH G.C.A.

During the war years the Americans developed a purely radar monitoring system for talking the aircraft right down to its final landing. The equipment included a system for directing the aircraft on to its final approach and an essentially separate system for bringing the aircraft down; the former is now known as the Surveillance Radar Element, the latter as the Precision Radar Element, and each is capable of functioning independently of the other. In this article we shall be dealing, but very briefly, with the Precision Radar Element only, the Surveillance being covered in the next and last article on aids to air traffic control.

(Concluded on Page 48.)

Our Gossip Column

Plans are now well in hand for the Monster Radio Ball to be held in the Metropole Cabaret, Auckland, on Thursday, 24th August. Sponsored by the Auckland and Provincial Radio Traders' Association, it is the first ever to be held in Auckland. An energetic committee is working overtime to make sure that everybody has the time of his life. Dancing will be from 8 p.m. to 1 a.m. and if we know Auckland, a whole lot of fun will be packed into those hours. Those requiring invitations are invited to communicate with the Secretary of the Association, Mr. J. E. Beachem, 24 Customs Street E, Auckland. Tickets may be purchased from Lewis Eady.

The Giles and Elliott personnel during a lighter moment.

In July Messrs Giles and Elliott Ltd. held a one week convention at Wellington, concluding with a cocktail party at Royal Oak followed by dinner. Further fun and games followed well up to the midnight hour. Managing director Bernie Giles says it was a fine ending to a very constructive week of "get-together."

* * *

Good wishes will be extended by many in the radio and electrical trade to Waldo ("Wally") Hunter who has started business on his own account in Acasia Buildings, O'Connell Street, Auckland. Wally, of course, was for 20 years with John's Ltd., and during the war served in New Zealand and overseas as a naval radar officer. Wally is developing wholesale trade and among the lines he has commenced with are "Hy-Live" coils produced by F. B. Menzies, a contributor to *Radio and Electronics* pages. Another new line which Wally is producing is the "Wayfarer" car radio.

* * *

Eric Peterson is the new radio manager for N.E.E.Co. Eric has now considerable experience in the radio trade, being in the radio department at Turnbull and Jones, Wellington, for some time and is an enthusiastic "ham" being well known in this sphere as ZL2DJ since 1929.

Also joined N.E.E.Co.'s Wellington branch is Angus Fergusson who will be handling cable sales, motors, and other industrial equipment. He is well known throughout all branches of the electrical trade, having had some 20 years' experience in various capacities.

Several changes of staff in the radio field have recently taken place and include Ivan Cosgrove, resigned after many years' service with National Electric Co. to join Grover Electrical Co. Ltd. as sales manager. Sid Davidson is again with Swan Electric Co. Taking over as manager for Fears is Harry Bradbury. John Martin from "Egil" has joined Swan Electric. Bob James, late of Philips is joining Grover's sales staff. Roy Scullen has been transferred to Christchurch branch of Arnold and Wright. We wish these old friends every success in their changes.

* * *

Two recent services introduced by this magazine to assist readers in the pursuance of their hobbies have proved themselves, judging by the calls for supplies. We refer to the technical photograpic service and binders. That *R. & E.* copies are useful at any time is apparent by the call for early photographs as well as the more recent ones. At times we have had to dig well down into our files to locate the original prints. It has been a test for our filing system and we are glad to report that that has proved infallible.

Binders are selling well and we appreciate the many favourable comments passed on to us for producing this utility cover at a reasonable price. A further order has been placed with our printers to take care of orders to cover the present volume five.

Leaving by air for England and Australia is Don Cooper, managing director of Green of Cooper, Ltd. He expects to be away for two months, spending most of the time in England contacting the principals of the various agencies which his firm represents in New Zealand.

Mr. C. W. Salmon, managing director of Cory Wright and Salmon, who has spent several months visiting the United Kingdom and the Continent, returned to New Zealand in July.

* * *

G. A. Wooller and Co. Ltd. have been appointed New Zealand distributors for Autocrat Radio Ltd.

CLASSIFIED ADVERTISEMENTS

Rates are 3d. a word, with a minimum charge of 2s. Advertisements must be to hand in this office not later than the tenth day of the month in order to be published in the issue appearing at the beginning of the following month.

While all care will be taken, no responsibility can be accepted for errors. Advertisements should therefore be submitted either typed or printed in block letters.

Book Reviews

Frequency-Modulated Radar, by David G. C. Luck; publishers, the McGraw-Hill Book Company, Inc.

Compared with the tremendous effort that has been put into the development of pulsed radar systems, the total effort so far applied to FM radar has been very small. Its importance first became apparent through its use as the basic principle of the radio altimeter, which was used widely in military aircraft by all major combatants in the late war. Frequency modulated radar differs from "ordinary" or pulsed radar in that C.W. transmission and reception is used, and the two functions thus go on continuously and simultaneously. The useful output of all frequency-modulated radar equipment takes the form of a beat note between the transmitted and received frequencies, the frequency of the beat being dependent upon the range and speed of the target, or reflecting object. FM radar is thus pre-eminently suitable for applications in which the principal answers required are measurements of range and speed. It also has advantages over pulsed radar in that relatively easy discrimination is possible between fixed and moving targets. The output of the radio equipment may be used in a remarkably simple manner to produce various automatic control functions, in accordance with target distance or speed, either individually or together. Practical applications along these lines that have already been successfully put into practice, are automatic control of aircraft altitude, and the release of missiles.

It has been found that signal-to-noise ratio, and therefore maximum range, is of the same order for FM and pulse radar systems of the same average transmitter power, so that for some applications, the former has the distinct advantage of not requiring high peak powers such as are essential to pulse radar.

Apart from the radar altimeter, most special radar systems of the FM kind that have either been suggested or actually built, have been directed towards solving various aspects of the problem of attacking surface vessels from aircraft. The radio frequencies used have been mainly on bands in the neighbourhood of 450, 1500, and 4000 mc/sec.

The present volume is a comprehensive treatment of the principles of FM radar, with much stress placed on its possible military applications. Indeed, the author states in his preface that the book was initially written as a final report to the U.S. Navy on the programme of research and development undertaken under contract by the RCA laboratories, beginning in 1941.

The material is presented in such a way as to give a comprehensive picture of the subject to one who has no previous knowledge of it, but who has a working knowledge of the principles and practice of normal radio engineering, together with some knowledge of pulse systems and serov-mechanisms. Considerable space has been devoted to a discussion of the mechanics of some of the problems that have been successfully met by FM radar. For instance, Chapter 5, of 45 pages deals with the kinematics of the problem of bomb release from aircraft. This is necessarily included, since an understanding of this subject is essential if the reader is to know what information is required from the radar set, let alone how it provides such information. Considerable space is also given up to complete descriptions of operational and developmental FM radar sets for various purposes, and it can be safely said that the book covers the practice of the FM radar art, as it exists today in the U.S.A., as completely as he has covered the theory.

It appears to the writer, after reading the book, that the relative simplicity and low cost of F.M. radar systems might bear investigation for certain navigational systems that do not yet appear to have been developed. For example, it does not seem unreasonable to expect that a small radar installation, light and cheap enough to be installed on even very small vessels, could be designed on the FM radar principle. Such a system could certainly not compete with the ordinary P.P.I. display in terms of quantity of information visible at one time, but could be very easily arranged to show the distances from the vessel to the shores of a narrow channel, for example. It could be used at the same time as a proximity warning device against possible collision with other craft. Such a set would not be very costly, but the importance of the relatively small amount of information it would give is such as to render it a useful navigational aid.

We would strongly recommend the book to all those who wish to keep abreast of at least some of the multitudinous things that modern radio is called upon to do, and does with such outstanding success that it ceases to be a wonder, even to the uninitiated.

* * *

Short-wave Radio and the Ionosphere, by T. W. Bennington of the Engineering Division, British Broadcasting Corporation, 2nd Edition.

All who carry on radio communication over long distances by short waves—whether professionals or amateurs—must be interested in the role of the ionosphere, which is one of paramount importance.

This book presents all the available information in simple form so that it is of use to those with only a limited technical knowledge. The author is a member of the Engineering Division of the British Broadcasting Corporation and has been able to draw freely on the Corporation's experiences in the development of short-wave overseas services.

The use of mathematics has been avoided and the physical processes involved are explained in simple descriptive language. The author has kept the practical side of the subject in mind throughout and shows how existing ionospheric data can be applied to everyday problems of short-wave transmission and reception.

This new edition of the work first published six years ago (under the title *Radio Waves and the Ionosphere*) is to all intents and purposes an entirely new book. Mr. Bennington has completely rewritten it; it has been re-set in new type; and 56 new illustrations have been added.

Contents include: Preface. Fundamentals of Long-distance Communication. Formation and Structure of the Ionosphere. Radio Waves and the Ionosphere. Measurement of the Ionospheric Characteristics. Ionospheric Variations—Short-wave Transmission. Multiple-hop Transmission and Ionospheric Forecasting. Amateur Transmission on High Frequencies. Radio Noise, Ionospheric Absorption, and the Low Limiting Frequency. Ionospheric Storms and Other Phenomena. Conclusion. Index.

* * *

Communication Circuit Fundamentals, by Carl E. Smith; publishers, the McGraw-Hill Book Company, Inc.

A book covering the physics of circuit elements, including vacuum tubes, and the fundamentals of D.C. and A.C. circuits, this is the second in a series on *Radio Communication Engineering,* and follows an earlier text, *Applied Mathematics for Radio and Communication Engineers,* by the same author. Each chapter presents the theory, develops design equations, and applies them to practical problems, completely worked out in the text. At the end of each chapter are a number of problems for the student to work, and answers to these are given at the end of the book. An excellent text for the serious elementary student.

Television Demonstrations In South Africa

More than 5000,000 visitors to the famous Rand Agricultural Show held in Johannesburg from 1st April to 10th April last saw "live" television shown in South Africa for the first time.

Demonstrations were given by the two British firms which were recently Britain's sole representatives at the first international television conference in Milan. They are Marconi's Wireless Telegraph Company Limited, and Cinema Television Limited (a J. Arthur Rank Group Company).

The demonstration was organized in South Africa in co-operation with the South African Broadcasting Corporation, by African Consolidated Theatres Ltd., whose chairman, Mr. John Schlesinger, first conceived the idea for the show and agreed plans with Mr. Rank during a visit to London.

Although a general service to viewers cannot be introduced into their territory for several years, the South African Broadcasting Corporation are closely following all television and research developments abroad. They have shown particular interest in the development of television and cinema-television equipment which has been carried out in Britain.

Until now South Africans have had to be content to read about the television programmes which are broadcast daily in England and America. At the Rand Show they saw "live" television demonstrated by Britain engineers and specialists using the most advanced British equipment. The personnel and equipment were flown out to Johannesburg and flown back immediately after the show.

Among the television developments which were seen by South Africans were transmissions received on domestic television sets and simultaneously projected on to a full-size cinema screen; a complete two-camera television studio in action; and a portable outside television unit working "in the field."

A glass panelled studio was built inside the television hall to enable 500 people at a time to watch television transmissions being made. Simultaneously they were able to view the scene in the studio in ten Bush television home receivers suspended above the glass panels. Viewers then entered an adjoining room where they watched the same programme on a cinema screen.

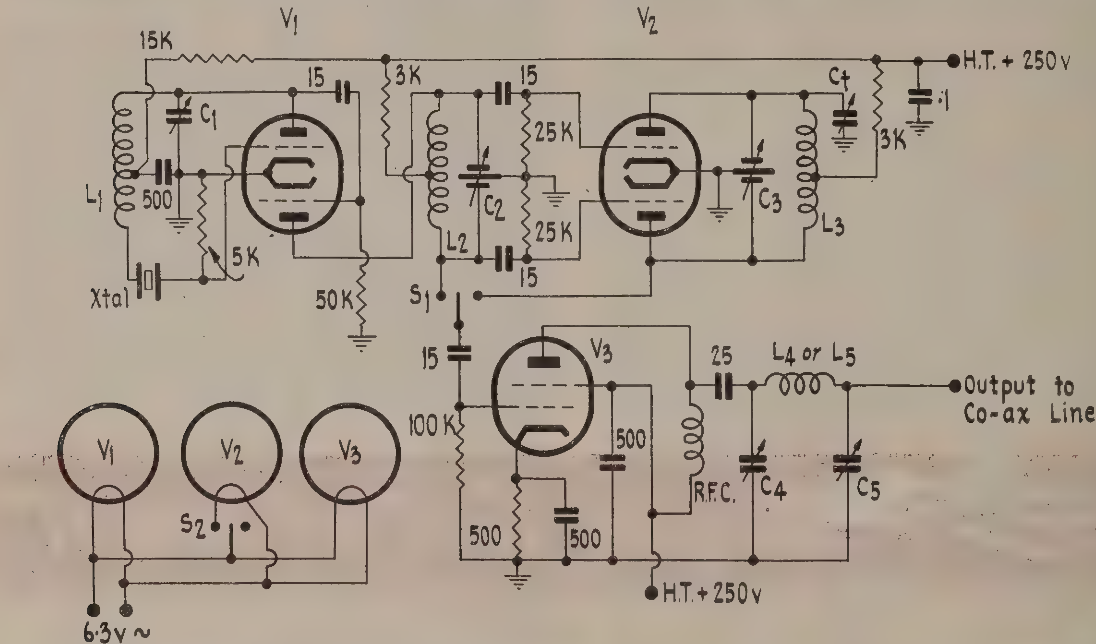
The interior of the television hall had been specially adapted for this demonstration to ensure the highest standard of technical performance. It was air-conditioned throughout to provide the maximum comfort for visitors.

An advanced technique of television design and manufacture, developed by Marconi's Wireless Telegraph Co., Ltd., enables the equipment of the outside television unit to be built into containers no bigger than ordinary suitcases. This unit visited places of interest within the grounds of the show and transmitted pictures back to the television hall.

The PHILIPS Experimenter

An Advertisement of Philips Electrical Industries of N.Z. Ltd.

No. 34: A Low-powered Transmitter or Exciter for Six and Two Metres



C_1, 75$\mu\mu$f. max. C_2, 36 $\mu\mu$f. max per section.
C_3, 10 $\mu\mu$f. max. per section. C_4, 17.5 $\mu\mu$f. max.
V_1, V_2, ECC91.
V_3, QV04/7.
C_5 100 $\mu\mu$f. max.
Note.—All capacities in $\mu\mu$f. except for H.T. by-pass: 0.1 μf.

PART I

In amateur radio, history has a habit of repeating itself. This is especially true in respect of the improvement of technique which gradually takes place on a particular band. Time was when self-controlled oscillator transmitters could be used with impunity on 80 metres, and as each higher band has been opened up, the last item to receive serious consideration has been frequency stability. This has then been improved in proportion to the number of people using the band, because if things were left at the self-excited stage, so few signals could be accommodated in each small slice of the radio spectrum. The bands at 50–54 and 144–148 mc/sec. are no exception, in that more and more amateurs are using them, with the result that crystal control is becoming a necessity despite their relatively great width. The trouble is that as one goes higher and higher, it usually becomes more complicated and costly to apply crystal control. But modern techniques tend to keep up with requirements, so that the development of high-frequency crystals and new circuit dodges enable simple crystal control to be relatively easily obtained without an inordinate number of frequency-multiplying stages.

The purpose of this Experimenter is to show how a reasonable amount of R.F. can be generated on both the above-mentioned bands, with crystal control, and only three valves!

The basic scheme is one which was described in *QST* some months ago, and which enables a double-triode valve to give useful output at six times the crystal frequency. Of course, the success of the scheme depends also on the existence of crystals with a fundamental frequency of between 8 and 9 mc/sec., and on the use of suitable valves. Ordinary receiving types are certainly not the thing at these frequencies!

THE SYSTEM USED

The exact positions of the six and two metre bands are very convenient, in spite of the fact that they are not in harmonic relationship. That is to say, output on 50–54 mc/sec. can be obtained by multiplying six times from crystals between 8.333 mc/sec, and 9 mc/sec., while output on 144–148 mc/sec. is got by multiplying 18 times from crystals between 8 and 8.222 mc/sec. Thus, except for crystals between 8.222 and 8.333, any crystal between 8 and 9 mc/sec. will multiply into either the six or the two metre band. Now since we have a circuit which will give six times crystal frequency, with reasonable power output, it is possible to have a single-valve oscillator-multiplier, followed by a straight amplifier for six metres, and then, by switching in an extra tripler stage, to excite the final amplifier on two metres. The only circuit changes necessary to go from one band to the other are to plug in a different crystal and a different output tank coil. We thus get two-band operation with only three valves. At the same time, the 2-metre band can

be tripled to hit the 420 mc/sec. band, so that the circuit presented here is able to form the basis of a crystal-controlled transmitter for all New Zealand bands from 50 to 460 mc/sec.

THE CIRCUIT

It will be seen that the oscillator circuit is very similar to a conventional plate-tuned tickler-feedback oscillator. L_1 comprises both the tuned winding and the tickler, only the portion above the tap being tuned. Instead of an ordinary grid condenser we have the crystal. The holder capacity, of a few micro-microfarads, acts as the grid condenser, and the crystal acts as a filter. At the series-resonant frequency of the crystal, the latter has a very low impedance, and amounts to virtually a short cricuit at this frequency. At all other frequencies, the series impedance of the crystal is high, and is able to prevent the circuit from oscillating. But it will be noted that the oscillator tuned circuit is at three times the marked frequency of the crystal—*i.e.*, from 24 to 27 mc/sec., so that it is not the fundamental resonant frequency that we are using, but the third harmonic. That is to say, the crystal is being called upon to vibrate not in its fundamental mode, but in a different manner altogether. It so happens that the crystal is able to vibrate in third and fifth harmonic modes, and the circuit can be set up so that the oscillator section of the first ECC91 is actually producing output at these frequencies. This is in contradistinction to circuits like the "tritet," where the crystal is actually oscillating at fundamental frequency, and multiplication is taking place in the electron stream of the valve.

The present arrangement should not be confused with the use of the so-called "harmonic cut" crystals. These are made in a special way so as to reinforce the harmonic vibrational mode (usually third) and are marked with the output frequency, not with the fundamental frequency which corresponds to their thickness. In practice, it is found that when we take an ordinary crystal, as here, and force it to vibrate in a harmonic mode, the output frequency is not *exactly* three times the marked frequency. This is understandable, since there is no reason why if the mechanical vibration is in a harmonic mode, it should be exactly a multiple of the frequency obtained when it vibrates in the fundamental mode. This fact should be taken account of, and it is desirable to check the actual output frequency obtained in the circuit, rather than to assume a frequency of three times the marked one. The circuit requires rather more care in adjustment than the conventional crystal oscillator, and it is essential to test whether the oscillation is in fact crystal controlled, or is a free oscillation, irrespective of the crystal. This can easily be done with the aid of a beat-frequency meter, and the procedure will be described

(Continued on Page 41.)

For the Serviceman

THE ULTIMATE
MODEL. R.A.C. 5-VALVE BROADCAST

Alignment Data: I.F.

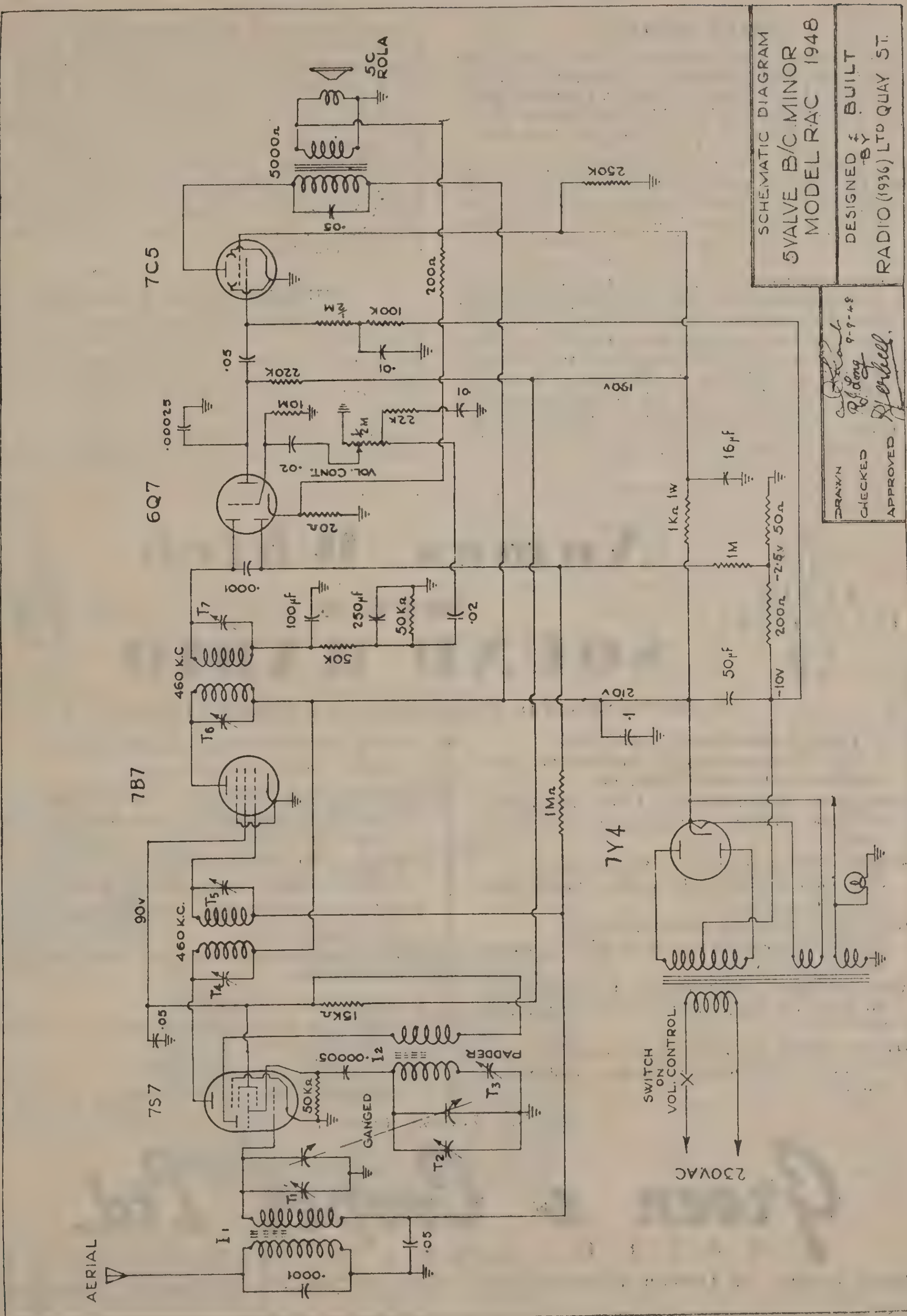
A signal generator modulated 30 per cent. at 400 cp/s is coupled to the control grid of the 7S7 by means of a .1 μf. condenser. The trimmers should be adjusted for maximum output in the following order.-

RF. Calibration

The pointer should be set in the horizontal position with the gang cords vanes unmeshed. Set pointer to the 1400 kc/s point on the dial and adjust T2 until 1400 cp/s signal corresponds. Set pointer to 600 kc/s point on the dial, and adjust T3 until 600 kc/s signal corresponds. Set pointer to 1000 kc/s point on dial and adjust I2 until 1000 kc/s signal corresponds. Repeat procedure until calibration is correct.

R.F. Alignment.

A signal generator modulated 30 per cent. at 400 cp/s is coupled to the ant. by means of a standard dummy ant. Set pointer to 1400 kc/s and generator to 1400 kc/s adjust T1 for maximum output, set pointer to 600 kc/s and generator to 600 kc/s adjust I2 for maximum output. If calibration has been accurate 1000 kc/s should be in alignment. Adjust intermediate points by means of forming gang cords; checking all previous adjustments.


SCHEMATIC DIAGRAM
5VALVE B/C MINOR
MODEL RAC 1948
DESIGNED & BUILT BY
RADIO (1936) LTD QUAY ST.
DRAWN
CHECKED
APPROVED
9-9-48
AERIAL
7S7
7B7
6Q7
7C5
7Y4
5C ROLA
460 K.C
460 K.C.
GANGED
PADDER
VOL. CONT.
SWITCH ON VOL. CONTROL
230VAC
90v
190v
210v
-10v
-2·5v

TRADE WINDS

A new company with objects as warehousemen and distributors has been registered in Auckland by Westco Distributors Ltd., Uc. Capital, £10,000 in £1 shares, shareholders Westonhouse Radio Ltd., 9996 shares, E. A. Tretby, A. Woodwill, and E. M. Fort one share each.

* * *

Dave Reid has severed his connections with Swan Electric Co. after 12 years' service, to start on his own account. Dave will be manufacturers' representative for radio and electrical lines and will operate throughout New Zealand from headquarters in Auckland.

* * *

We have received some interesting letters from some of the radio operating team who recently went to Heard Island with the Australian Antarctic Research Expedition. One particular communications receiver used was loaned by makers of "Eddystone" and the operators say that while contending with temperatures which fell to a minimum of 13 deg. F. and aurora conditions making things difficult, communications were well maintained with many countries, apart from the pleasure derived from listening by way of recreation.

Swan Electric Co. has opened a sub-branch at Main Street Palmerston North in charge of Sid Davidson. This, says Brig Mason, will enable the company to provide a more direct service to the trade in the Manawatu, Taranaki, and Hawke's Bay districts. Sid says that at the moment the housing situation is his headache but he has hopes of settling down in his home town shortly, this after 16 years' absence. When his new home is established Sid hopes his many Wellington friends will look him up for a social call, and he also wishes us to extend his thanks for many courtesies shown to him by members of the trade during his many years in the Wellington district.

* * *

PUBLICATIONS RECEIVED

From Amalgamated Wireless Valve Co., Australia, "Radiotronics," No. 142, and Chart for Radiotron 7-pin miniature tubes. Also copy of Federal Communications Commission's Standards of Good Engineering Practice concerning Televison Broadcast Stations, effective December 19th, 1945.

Lamphouse Annual, 1950–51 is as usual brim full of interest to radio fans. With no sparing in the cost of

production, the annual, as always, is a good shilling's worth and more and this one, perhaps deserves credit for being the best of the post-war issues.

From Electronic Navigation Ltd., Decca News No. 1. We hope to review this in a near issue—it has just come to hand and promises to be of special interest in the radar-navigational circles.

From H.M.V. N.Z. Ltd., Technical Data on the application of "His Master's Voice" No. 12 Pick-up. Bulletin 4A. "H.M.V." controlled-heat iron.

Electrical Utilities Co. Ltd., leaflet, "Eutron Element for Every Purpose."

Arnold and Wright Ltd., leaflets on "Arnrite" receivers, water heaters, etc.

Bradley's Electrical Co. Ltd., retail price list and literature of "Master" instruments and electronic test equipment. Leaflets on "Cressall" radio components and electrical products. Brochure on "Welwyn" high-stability carbon resistors.

Industrial Electronics Ltd., bulletin on F.M. Transmitters, by Rhode and Schwarz (Dawe Instruments Ltd., England).

W. G. Leatham, Ltd., range of catalogue leaflets by Fielden (electronics) Ltd., England, covering electrical measuring and testing instruments. TEKTO Instruction Manual, also leaflet of Wayne Kerr on Audio Frequency Impedance Bridge, V.H.F. Admittance Bridge, and other instruments.

Green and Cooper, Goodman loudspeaker catalogue of data sheets.

Electro Technical Industries Ltd., price list on British "Oak" switches.

"Williamson Amplifier," collection of articles on "Design for a High-quality Amplifier" by D. T. N. Williamson, formerly of the M.O. Valve Company, now with Ferranti Research Laboratories. Published 20th April, 1950, at 3s. 6d. (postage 2d.) for *Wireless World*, by Iliffe and Sons Ltd. Size 9¾in. x 7¼in. 36 pages and 31 illustrations.

This 15-watt amplifier has gained world-wide recognition among quality-reproduction enthusiasts for its remarkably low harmonic and intermodulation distortion. The response curve is flat within 1 db. up to 10 k/cs. Direct coupling in the first stage helps to reduce phase shift, which is negligible over the range 10 c/sec.–20 kc/s.

Input for the main amplifier is 1.9v. peak. With a simple record-compensated pre-amplifier it is 18 mv; 1.3mv for use with microphones and under 1 mv. with a high-gain pre-amplifier.

The various issues of *Wireless World* in which the amplifier was originally described have long been out of print; in this booklet all information published since 1947 on the amplifier has been collected and edited for easy reference.

The booklet gives full details not only of the basic circuit, but also of ancillary equipment recommended by the designed for high-quality reproduction of records and radio programmes. Circuits for correcting recording characteristics are included and also high- and low-pass filters, the latter variable. There is a fading control for reducing gain to zero when changing records; the rate of fading is automatically controlled.

Contents include: Introduction. Basic Requirements: alternative specification. Details of chosen circuit and its

(Continued on Page 48.)

Photo Finish Applied to the British Empire Games, 1950

The application of photo-finish for the athletics in the British Empire Games while being essentially the same in principle as the system used for horse-racing in this country, nevertheless required considerable modification for efficient fool-proof interpretation of athletes and cyclists, the events for which photo-finish was required by the Games Committee.

There were three major problems and a multitude of tricky points which did not apply to horse finishes where experience in thousands of races, and having extensive facilities has ironed out and resulted in a smoothly operating and efficient system.

(1) NIGHT EVENTS

Night events had never before been photo-finished in the true sense of the word in this country. The problem, of course, was one of lighting.

The cameras were 45 ft. above the ground, tilted at an angle down on to the track. The distance from the cameras to the track was 76 ft. The speed of the cyclists, the focal length of the lens and the camera distance necessitated a film travel in the camera of 3.2 in. per second. A film speed of 3.2 in. per second with a slit of .005 meant an equivalent of 1/640th second shutter speed. (There is no actual shutter, of course.) Photographically minded readers who will realize that obtaining a good photograph on a still camera from 76 feet and a shutter speed of 1/640 in open space even with flash is quite difficult, will fully appreciate the problem involved in sustaining adequate illumination for 10 or 12 seconds continuous operation on a basis of 1/640 at f. 4.5.

(2) NO MIRROR ALLOWED ON THE OPPOSITE SIDE OF THE TRACK

In horse-racing photo-finish, the better systems incorporate a mirror on the opposite side of the track to the camera. Horses often finish at the post in a very "bunched" state. From a horizontal position opposite the horses it would often be impossible to separate them—if the horse closest to you was ahead of the others, his body could obstruct the second, third, and perhaps the fourth places.

The greater elevation you can have the better—the farther you have to be from the course, influenced by such factors as "birdcages," etc., the higher your camera positions must be for efficient operation. As some courses require the towers well back, considerable height would be necesarry, even 70, 80, or 90 feet, but for the use of a mirror.

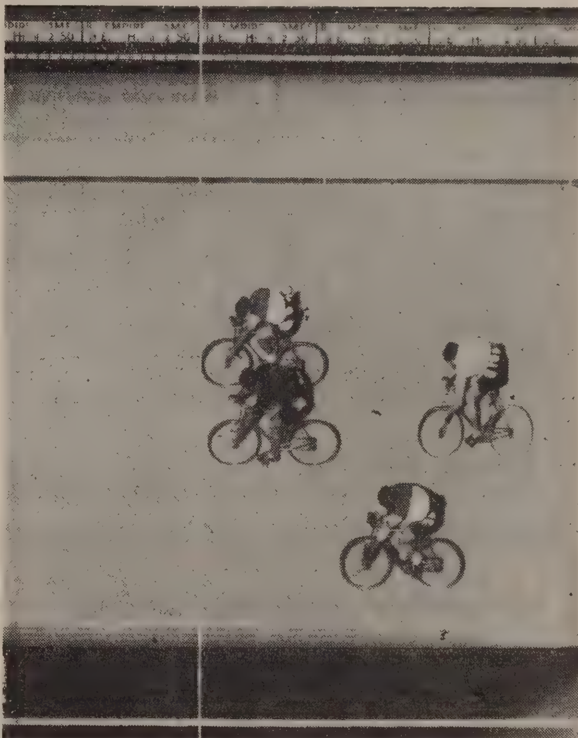
With the British Empire Games, track officials could not allow the mirror structure obscuring their line of vision, consequently the towers had to go to such a height that freedom from obstruction amongst contestants could be guaranteed.

Thus the towers covering but a 30 ft. track, and only 18 ft. from the edge, had to be 40 ft. in height. Had the towers been only 25 ft. high the chances were probably one hundred to one that it would separate all finishes successfully.

Uninitiated "experts" were certain they need not be any higher. However, careful calculations showed that with one runner finishing on the outside, and another on the inside of his lane in certain bodily positions, in a tight finish, obstruction could occur with anything under the height we stipulated. This height, revealing the track more in plan required a wider angle lens with consequent smaller athletic images and slower film traverse.

As events proved, obstruction would have occurred in two races had the towers been lower. As it was every race was separated perfectly.

This separation referred to is, of course, lateral separation—not the separation in order of placings which must be exact. The only question is one of being able to see them unobscured, thus the importance of avoiding visual interference.



A photograph from the photo-finish equipment at the Empire Games. It shows Heseltine winning by 1/200th sc. from Lock.

(3) NO LONG NEON TUBE POSSIBLE FOR ALIGNING

For accuracy in lining the installation, and proving it is on line, the photo-finish system on horse-racing utilizes either a spinner, lined and centred, or a neon tube 3 ft. in length situated in the winning post structure. This is plumbed vertically in the finish line. To the lay person this tube is merely a "bar" of light—to the electrically minded it is a discharge tube flashing 100 times a second on the 50-cycle alternation.

As the film is passing at a constant speed, each time the tube flashes it produces a little vertical bar along the centre of the film like a "picket fence" with bars 1/100th of a second apart, the separation between "bars" depending upon the speed of film travel.

The image of this tube in the finish line is projected directly on to the slit in front of the film and, as the cameras are centrally located on a projection of the finishing line, and the slit in front of the film is only .005 in. in width, one can almost say the cameras are

optically "pinned" on line, for obviously if they became twisted the slightest fraction off line, the image of the tube would no longer lie in the slit and consequently would not record on the film.

It will be seen therefore that the registration of this "fence" of vertical "blips" across the photograph is proof that the camera is on line.

If the finish line, registered vertically across the point in the enlarger, lies through, or parallel to one of the neon verticals, is at right angles to the flow line, and touches exactly the same points of both the direct image horses in the lower section of the picture, and the reflex images in the upper section of the picture, it must be seen that the aligning is pretty well perfect.

Again, as in the case of the mirror, this long neon could not be used in the Games. It therefore became necessary to adopt a different system though it was desirable to retain a "blipper" for its timing value.

Special 3 in. neon tubes were manufactured which straddled the track, sunk into the ground in line with the leading edge of the finishing line. The tubes were set in position in a surveyor's presence, the cameras clamped into drilled steel plates adjusted by theodolite from the finish line, then with the cameras levelled, the optical images of the two neon blippers, one at the top and one at the bottom of the slit—in the case of the athletics only .003 in. in width—it is obvious that if both the blippers showed on the photograph it must be dead on line.

It was interesting to note the degree of accuracy in timing the separation between competitors with the blips on the film. Where a stop-watch records only to 1/10th second, the camera with neon tube actually freezes the situation into a static diagram in which separations are registered in principal graduations of 1/100th second and can easily be subdivided to 1/400th second.

In the case of the cycling which was fast, 1/100th second on the judges' print was represented by 4 mm. width.

In the 10-mile cycling race Heseltine of Australia can be seen beating the New Zealander Lock by 2 mm. on the original photograph, where the 1/100th second blipper is represented by a flash 4 mm. in length, which gives the distressing answer that the New Zealander was beaten by 1/200th second.

A journal recently in publishing some of the British Empire Games photographs included a caption to the effect that the distances between the places was misleading due to photographic distortion.

This is, of course, quite inaccurate. It must be obvious even from the foregoing that nothing can register until it hits the line (that is, photographically, the slit) and it must register exactly as it does reach it. Actually it is the eye that is misleading—everyone knows that visual perception and persistence is slow comparatively, as can be proved by the fact that a motion picture on the screen appears to be one continuous picture whereas in actual fact you have pictures and darkness alternating as slowly as 24 times per second.

Distortion of the actual competitors' image can occur due to angles and synchronism resulting in athletics in a fat man or a thin one, but the leading "edge" of man, beast, or vehicle must reach the slit and register in exactly the time and order in which they reach the finishing line.

A 3 in. Oscilloscope

(Continued from Page 16.)

all the other panels. This improves the appearance of the front panel.

The view of the inside works, shown on this month's front cover, shows how the amplifier tubes are placed right way up, with the time-base tube upside down in front of the X amplifier valve. This places the time-base wiring very close to the coarse frequency switch and the fine frequency control, enabling the wiring to be kept short. At the same time, it partially shields the time-base circuit from the amplifiers, helping to prevent cross-talk, and also the time-base from getting into the X amplifier when the former is running, but not connected to the amplifier by means of the terminals on the front panel. In addition, with such a small chassis, there would not be enough room for all the small parts underneath. The leads to the brilliance and focus controls carry only D.C., and so are cabled and led from the C.R.T. socket to the front panel. The two output leads from each amplifier are twisted together and taken through rubber grommets in the back of the chassis to the tube socket. The condensers that can be seen at the back of the instrument are taken to banana sockets, one from each deflecting plate. These condensers are not shown in the circuit diagram. Their value is 0.1 μf. rated at 600 volts. These banana sockets enable voltages to be connected without the intervention of the amplifiers, where these are not needed, and the blocking condensers, as well as isolating the positive voltage of the deflecting plates from the external circuit, enable the shift controls still to work. An interesting point is that even when the Y amplifier is not in use, it is possible to use the synch. control, since the voltage divider which feeds the suppressor of the time-base tube is connected through a condenser to one of the deflecting plates. Thus, when direct connection is used, both shift and synch. controls function.

Apart from showing where the main components are mounted, there is little that can be said about the wiring up of the unit. This is quite straightforward, and follows normal audio amplifier practice, and so needs little comment in any case.

SETTING UP

When the wiring has been completed and checked, all valves should be plugged in and the power turned on. It is necessary to have the amplifier valves in their sockets because if they are not, there will be violent spot de-focusing, and no settings of the controls will be found in which a sharp spot or line is obtainable. It is best to turn the time-base on to one of its lower ranges, and connect it to the X input terminal when the first tests are being made. A small spot, if left stationary for any length of time will burn a small area of the fluorescent coating that is the screen and it is advisable to have some deflecting voltage connected at all times. If all is in order, it will be possible to get a finely focused line at all settings of the brilliance control, but the best spot, and therefore the finest line, is obtained when the brilliance is rather lower than the maximum possible. Do not worry if the line is rather fainter at one end than the other. This is likely to occur because of the rather imperfect square-wave fed to the grid of the C.R.T. from the time-base circuit. The effect is only visible at fairly low brilliance settings, and should not cause trouble. If desired, a switch could be fitted disconnecting the condenser C_5 from the junction of R_{31} and R_{32}. This would disable the blackout circuit and enable the fly-back to be seen.

It is necessary, first of all, to adjust the balancing condensers and potentiometers of the amplifiers. The latter are mounted on the back of the chassis, and one of them can be seen in the photograph. To do this, a signal at some low audio frequency (say below 1000 c/sec.) can be fed to the Y amplifier input terminal, and the gain control adjusted so that a suitably sized deflection is obtained with the moving arm of the balancing potentiometer at the earth end. Then, the whole output voltage will be due to the first half of the valve as the second half will not receive any input voltage. The balancing potentiometer is then advanced until the deflection is exactly twice the previous amount. This indicates that both halves of the valve are now producing equal output voltages. The potentiometer has now been adjusted, and can be left set. The same procedure is gone through for the X amplifier. Next, the balancing condensers have to be adjusted. These have been recommended as Philips trimmers, and the correct setting will be found at or very close to minimum capacity. In order to check, a high-frequency audio signal, say 10,000 c/sec., is fed into the amplifier. This time, the second half of the valve is disabled by temporarily unsoldering the coupling condenser—C_6 and in the case of the Y amplifier—and a suitable deflection is arranged again. The condenser is replaced, and the balancing condenser is now adjusted until the deflection is twice the former figure. It is most important to note that the potentiometers must be adjusted first, and NOT TOUCHED THEREAFTER. The condensers cannot be adjusted unless the low-frequency balancing has already been done. After this, there should be no further adjustments needed. Should the picture become badly defocused at one side of the screen, and not at the other, it is an indication of a faulty C.R.T., as long as the amplifiers are all right. In order to test this, one should place a voltmeter across the Y plates, and adjust the Y shift control until no reading is obtained. The same procedure is followed for the X plates, and the X shift control. When this has been done, the meter is removed, and without touching the shift controls, the spot is turned up. The adjustment of the shift controls in the way described ensures that no shift voltages are being applied to the deflection plates so that when the spot is turned up it will land on the position on the screen governed solely by the alignment of the electrodes of the tube. It is not often found that the spot is exactly in the centre of the tube, and the makers allow tolerances in this respect. However, if the spot when undeflected, does not land within the prescribed limits of distance from the tube centre, it is possible to have it replaced. If, say, the spot is somewhat to the left, then it may be found that the focus at the RIGHT side of the screen is not so good. Then to get the best out of the picture it is best to allow the picture to sit over to the left ,in a position corresponding to that of the undeflected spot.

THE NEW ZEALAND ELECTRONICS INSTITUTE (Inc.) NEWSLETTER

GENERAL NEWS

Members are no doubt well aware that two postal ballots have been conducted recently. One of these postal ballots was to amend the rules and the other was to ascertain whether members would be prepared to vote for an increase in subscription in order to receive each month the official organ of the Institute, viz. *Radio and Electronics*. The official results of these ballots have been notified to members but for those others who have not yet received an official result we would advise as hereunder:

Alteration to Rules:

Section 5 formerly reading:

"Associates shall be entitled to vote, but shall not be eligible to hold office on the Council or on the Admissions Committee"

has now been altered to read:

"Associates and students shall not be entitled to vote nor to hold office on the Council or on the Admissions Committee."

Section 5 (e) formerly reading:

"Students shall not be entitled to vote nor to hold office"

has been deleted completely.

Section 6—Associates (c) formerly reading:

"That being not less than 40 years of age and without examination qualifications he has knowledge of the theory and applications of electronic science of a standard acceptable to the Admissions Committee for this grade"

has now been altered to read:

"That being without examination qualifications he has knowledge of the theory and applications of electronic science of a standard acceptable to the Admissions Committee for this grade."

Section 21, a new rule, will be added to the constitution:

"If a Council member is unable to attend a Council meeting he may give his proxy to another Council member. No Council member shall hold more than one such proxy at a meeting."

Increase in Subscriptions to Cover the Establishment of a Journal

An overwhelming majority voted in favour of the Institute having its official journal, the actual result being:

For the establishment of a journal	59
Against the establishment of a journal	15
Informal	2

As it is proposed to institute the new system immediately, members would assist in the effective implementation of the ballot by forwarding their subscriptions promptly and this will then entitle them to automatically receive the official organ of the institute, *Radio and Electronics*.

The new subscription rates are:—

Member	£3 15 0	Includes free monthly issue of *Radio and Electronics* and subject to rebate of 5/- if paid before due date.
Associate Member	£2 15 0	
Associate	£2 10 0	
Students over 21	£2 0 0	
Students under 21	£1 10 0	

At the annual meeting held recently several members expressed opinions regarding the establishment of an official organ and now that this matter, together with the alteration in the rules has been finalized, it is felt that much progress can be made.

BRANCH NEWS

Auckland—Television Set:

In late 1947 Mr. I. C. Hansen, now Assistant Editor of *Radiotronics* made the suggestion that the Auckland Branch of the Institute should construct an industrial television apparatus to a circuit published in *Electronics* of June, 1947. In an appeal to a number of radio firms sufficient equipment, gear, and assistance was made available to finally complete the project. Mr. L. O. Hunter supplied the drawings, collected the parts and generally arranged for the work to be done. On test the assembled apparatus proved to be reasonably successful, so much so that the National Film Unit considered it worthy of publicity and shots of the apparatus in operation have been displayed on the theatre screens throughout the Dominion.

That is the story in brief but behind the scenes considerable technical knowledge, time, and effort has been expended by Institute members in Auckland to finalize the project and no doubt any reader desiring any further information could obtain it from Mr. L. O. Hunter whose address is 37 Court Crescent, Tamaki, Auckland.

Wellington:

Mr. F. R. W. Andrews of Telecommunications section of Civil Aviation, gave an address at the June general monthly meeting entitled "Conferences of the International Telecommunications Union." He dealt with the historical background of the Union, its composition and its function in the allocation and registration of frequencies and covered comprehensively the work of Region 3 and the Aeronautical Conferences of 1949.

At the July general monthly meeting, Mr. G. A. Eiby, M.Sc., gave an address entitled "Some Modern Methods of Time-keeping." He dealt with various methods of

time-keeping, leading up to a description of the molecular clock. Although the quartz crystal clock history goes to only as far back as 1940, stable oscillators had been in use many years before it was realized they could be used as time-keepers. It will come as a surprise to many to know that the crystal oscillator has only recently exceeded in accuracy the pendulum clocks used as time standards by the astronomers.

The results of the election of officers for the ensuing year conducted at the annual general meeting of the Wellington branch are as under:

Chairman: W. D. Foster.
Vice-Chairman: L. W. Hurrell.
Secretary: R. G. Currie.
Treasurer: J. D. McCormick.
Management Committee: The above officers, D. L. Rushworth and J. P. Senior.

Our new meeting room has been found to be most satisfactory and for the benefit of those who do not know its location: Conference Room, Air Department Building, Bunny Street, Wellington.

Dunedin Branch:

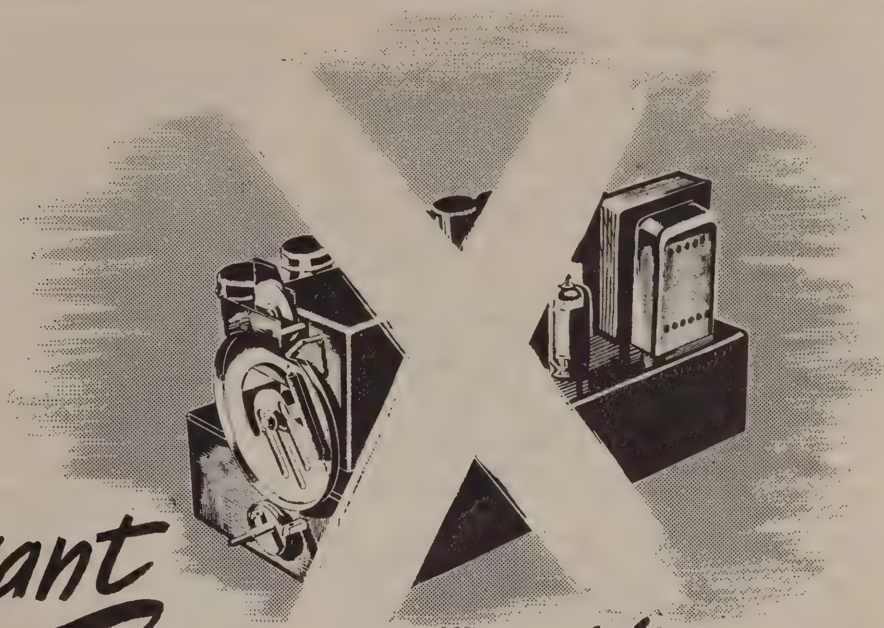
At the annual meeting of the Dunedin branch the following officers were elected for the ensuing year:

Chairman: W. L. Shiel.
Vice Chairman: H. F. Symonds.
Councillors: W. L. Shiel, H. F. Symonds.
Secretary-Treasurer: W. A. McInnes.
Committee: E. Anderson, W. Collett, J. Coombs.
Social Committee: J. Stone, T. G. R. McGregor, L. W. Clarke.

Christchurch Branch:

At the annual meeting of the Christchurch branch the following officers were elected for the ensuing year:

Chairman: Mr. Withers.
Vice-Chairman: T. R. Pollard.
Treasurer: Mr. Lee.
Secretary: A. V. Butcher.



Questions and Answers

"R.W.G.," of Christchurch, writes in connection with the oscilloscope circuit described in this and the last issue of *Radio and Electronics.* He says:

"I have read with extreme interest your article on "An Easily Built Oscilloscope" in the July, 1950, issue of your magazine, and intend to build it up. What interests me is the Osram E-4102, as I have a similar tube which I procured in England during the war. Unfortunately, very little data were supplied with it except the following: Type 23D, Ser. No. KL93, Fil. Volts 4, overall length, 7½ in., effective screen diameter, 2⅝ in. The base is like Eric has had considerable experience in the radio trade, an overgrown octal, with a key spigot and ten pins. I applied a potential between pins 3 and 4, and the tube lit up at what I would call normal brilliance. Below is a diagram of the underneath view of the tube. No maker's name is on the tube, but I think it is Cossor. Do you think it would be the same tube as the Osram E-4102? I have also a power transformer giving 6.3, 5, and 4 volts, and a secondary of 450–0–450 volts at 50 ma. Would this be satisfactory for the tube?"

This letter is particularly apposite at the moment, since we have discovered, as mentioned in Part II of the article in question, that no more of the Osram tubes can be expected to be available. Also mentioned, however, was the fact that the E-4102 was made to a standard design during the war by a number of manufacturers, each of which had his own type number for what was essentially the same tube. It does seem highly likely that the tube mentioned by our correspondent is identical in characteristics with the E-4102. The appearance of the base is identical, to judge from R.W.G.'s diagram, and the filament pins are Nos. 3 and 4 in both types. We would be very surprised if the remainder of the connections, as well as the characteristics are not identical with the original tube as used in the 'scope we have built ourselves, and which is illustrated in this issue.

With regard to the power transformer, this looks as if it would be ideal for the purpose, especially since it has a 4v. winding for the C.R.T., and it will not therefore be necessary to use a dropping resistor as we have done. There is only one point that will have to be watched, however, and that is the actual H.T. voltage that will be obtained from the power supply. As mentioned in the article, the low-voltage H.T. is approximately 400 volts, and the high voltage H.T., 800. This is with a 350-volt transformer, so that with a 450-volt one, the voltages could be expected to be 460 and 920, approximately. These voltages would mean that the actual voltage across the C.R.T. would be slightly over the rated maximum of 1200. It would be advisable, therefore, to increase the values of the smoothing resistors R_1 and R_3, until the voltages at their output ends are 800 and 400 respectively. The result will be supplies with improved smoothing, which is all to the good, in spite of the fact that it is already quite adequate.

Another small point is that the maximum A.C. input voltages for the 6X5 rectifiers is exceeded—it is in the E.H.T. rectifier in any case—but this should be of small concern, since it is well known that where the rectified current is much smaller than the normal maximum, it is permissible to increase the A.C. input voltage without harm being done to the valves. It is quite a common commercial practice to use low-voltage rectifiers in this

way, and it will be found that the 6X5's will stand up perfectly well in this circuit.

USING THE "VERSATILE TONE CONTROL"

The above circuit was described in the July and August issues, 1949, and gave a very simple and effective method of getting either attenuation or boost, at high and low frequencies, there being separate L.F. and H.F. controls. "W.S.S.," Dunedin, writes sending a circuit which he proposes to use, incorporating the above-mentioned circuit. It is on a tuner chassis, which is to feed the "New High-quality Amplifier," as described in the June, 1949, issue, and our correspondent has incorporated on his tuner chassis one stage of voltage amplification following the detector, the "Versatile Tone Control" circuit, and finally a cathode-follower, because of a long output lead to the main amplifier.

Now there is nothing basically wrong with such an arrangement, but unfortunately, W.S.S. has placed the parts in the wrong order. In other words he shows the diode detector followed by the tone control circuit, after which come the audio amplifier and cathode follower. This is quite wrong, because the tone control circuit has an input impedance at some frequencies of not much more than 50,000 ohms, and although no values are shown, the diode load resistor can be expected to have a resistance of ½ to 1 megohm. The volume control is shown as the diode load resistor, which is good practice, but the trouble is that at high settings of the volume control the low impedance of the following circuit would cause severe negative peak clipping by the detector—a particularly noxious form of distortion. However, nothing more is needed to fix up the arrangement than to change the order so that the A.F. amplifier grid is fed from the moving arm on the volume control (with the usual grid leak and blocking condenser, of course) and the tone control circuit is placed in the circuit between the A.F. amplifier plate, and the grid of the cathode follower. If this is done, all will be well. However, it should be noted that the A.F. amplifier stage can only have a load of 50k. or so—certainly no more—and should therefore be a low-gain triode, such as one half of a 6SN7. A high-mu triode should not be used, and the cathode resistor should be made according to the resistance-coupled amplifier table's recommendation for a 50k. plate load resistor.

The correct way to arrange the circuit is therefore exactly as was illustrated in the original article on the tone control circuit.

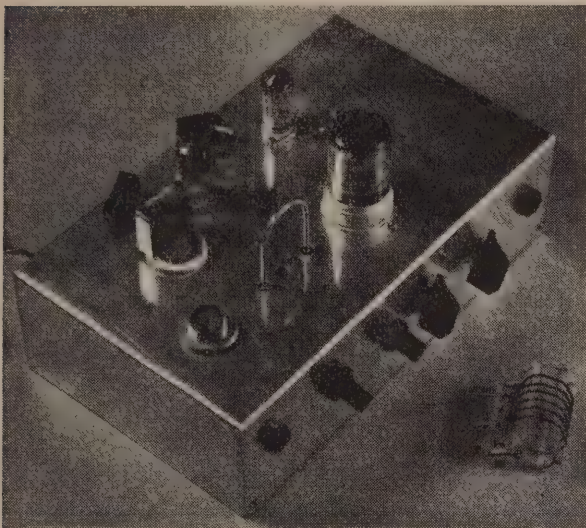
"RADIO AND ELECTRONICS"

Back and current numbers of "Radio and Electronics" may be obtained from—

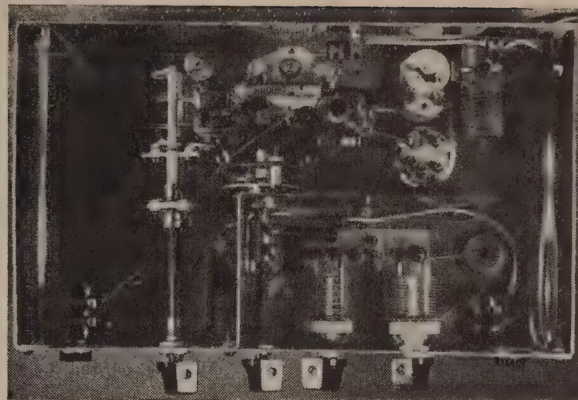
Te Aro Book Depot, Courtenay Place, Wellington.
S.O.S. Radio, Ltd., 283 Queen Street, Auckland.
S.O.S. Radio, Ltd., 1 Ward Street, Hamilton.
Tricity House, 209 Manchester St., Christchurch.
Ken's Newsagency, 133–135 Stuart St., Dunedin.

The Philips Experimenter

(Continued on Page 25.)



Top view of the exciter. The 144 mc/sec. output hairpin is shown in position, and the coil in front is the 50 mc/sec. output coil. The lay-out of parts is described in the text.



Underneath view. The oscillator circuit parts can be seen in the top right-hand corner in this photograph and the baffle shielding can be clearly seen enclosing the output tank circuit parts, and crossing the QV04/7 socket so as to isolate the plate circuit from the input side.

under the heading of "Adjustment."

The second half of V_1 is a straightforward doubler stage, with the grid capacity-coupled to the tuned plate tank of the oscillator. A balanced plate tank circuit is used, and it will be noted that the output stage is fed from the side of this circuit opposite to that connected to the plate. This has the desirable effect of helping to keep the stray capacities balanced when the bandswitch is in the 50-54 mc/sec. position. The strays associated with the switch also help to keep the circuit balanced when the succeeding push-pull tripler is being used.

(Continued on Page 46.)

High-fidelity Pick-ups

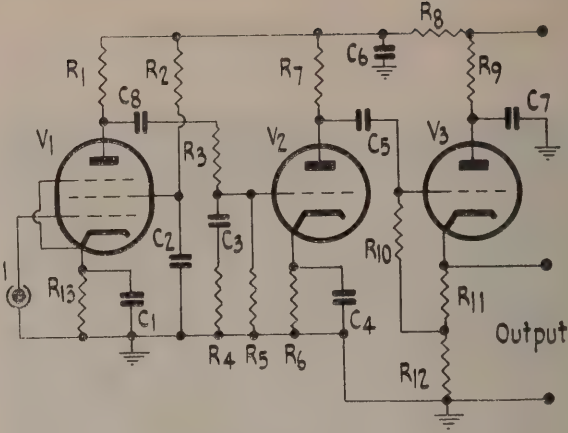
(Continued from Page 7.)

The heater circuit should not be grounded directly, but should be centre-tapped by means of a low-resistance potentiometer, say 100 ohms total resistance, or, failing this, by a pair of small, equal resistors, say of 50 ohms. The potentiometer is best, however, since the least hum is often found when the heater winding is not exactly centre-tapped. The potentiometer is adjusted for least hum. The heater winding should be earthed, not near the transformer, but as close as possible to the first valve, so this means putting the potentiometer or the separate resistors as close to the socket as possible, and, as mentioned above, earthing the centre-tap to the common earth-point of the stage.

If these precautions are taken, as recommended, the hum will be reduced to an acceptable level. It should be remembered that extra special care must be taken, not only on account of the high gain, but also because of the bass-boost that is being used. Although the middle-and-high-frequency gain is reduced by a factor of ten by the bass-boost circuit, the full pre-amplifier gain is gradually approached as the frequency falls below 300 c/sec., and is at maximum somewhat below 50 c/sec.

HUM-BUCKING BY THE PICK-UP WINDINGS

It was not mentioned in the first part of this article, but the manner in which the pick-up coils are wound gives a certain amount of automatic protection against hum-pick-up by the pick-up itself. The most likely source of trouble is the stray hum field of the electric gramophone motor. If much hum is present, one can test whether it is due to the motor by placing the pick-up on a stationary record on the turntable, with the motor switched off. Then, with the table held so that it cannot rotate, the motor is switched on, when an increase in the hum indicates pick-up from the motor. A four-pole motor



COMPONENT LIST

V_1, EF37 or EF37A.	R_{12}, 100k.
V_2, V_3, ½ECC35.	R_{13}, 2k.
R_1, R_7, 250k.	C_1, C_4, 25 μf. 25v. electro.
R_2, 750k.	C_2, 0.25 μf.
R_3, 200k.	C_3, 0.05 μf.
R_4, 20k.	C_5, C_8, 0.02 μf.
R_5, R_{10}, 1 meg.	C_6, C_7, 16 μf. 450v. electro.
R_6, R_{111}, 5k.	J_1, input jack, shielded.
8_8, R_9, 50k.	

is preferable to a two-pole motor, because it has a smaller stray 50 c/sec. field around it, and a motor unit is to be preferred that has a heavy non-magnetic turntable. Sometimes, it is possible to greatly reduce the hum level by placing an extra layer of felt on the turntable, thus raising the pick-up head slightly, off the turntable. A rather strange phenomenon was noticed with the original pick-up, and it is quite likely that others may strike the same thing. It was noticed that although the hum was not excessive, even with the temporary pre-amplifier that had been constructed, the cone of the speaker was performing very wide excursions at a low-frequency rate. Investigation showed that this disturbance was hardly present near the outside of a 12 in. record, but was very bad at the start of a 10 in. one, getting progressively smaller towards the end of the record. A check showed that it started suddenly, with all records, when the arm was in a certain position, which, on further investigation, turned out to be the place where the radial strengthening ribs under the turntable started. With the aid of the oscilloscope, it was found that the frequency of the spurious signal was round about 8 c/sec., and when the ribs were suspected, a count of the ribs, taken in conjunction with the known rotational speed of the turntable, gave a calculated frequency of 7.9 c/sec., there being six ribs! The disturbance was due not directly to the stray field of the motor, but to its modulation by the turntable ribs as they passed close to the pick-up head! All of which goes to show that where gear is used which will respond without sensible drop at 20 c/sec., frequencies very much lower than this are passed through, and can cause trouble in the speaker itself. The correct cure would be to insert a high-pass filter between the pick-up and the pre-amplifier. The filter

(Concluded on Page 48.)

LETTER TO THE EDITOR

Sir,—Your recent article on the construction of a high-fidelity pick-up will no doubt be widely read and create a great deal of interest, particularly with the ever-increasing community of people who enjoy the reproduction of records as near to the original as possible.

However, you make some statements which cannot go unchallenged. Firstly, that no pick-up is available in this country employing the feature of vertical compliance. It is a fact that Brierley "Ribbon" has vertical compliance. Now this is a very important feature as you rightly point out but is no monopoly of the U.S.A. In fairness to "Brierley" it is suggested that you publish a correction.

Now for the second point: You say it is a comparatively simple matter to construct a preamp. for an input of 1 millivolt. Well! here is indeed something! Mr. D. T. N. Williamson says that 7 millivolts is about the lowest input that can be handled. J. H. Brierley has published full details of his preamp. for an average input of 5 millivolts, and although its construction presents no difficulties for the experienced constructor it is full of pitfalls for the unwary, especially when, as in this case, the preamp. obtains its filament and H.T. supplies from the main amplifier.

If you mean an input of 1 millivolt to the primary of an input transformer then, of course, the problem will be simplified somewhat. However, an article of this type will be of very great interest to hundreds of your readers and will do a great service to those who are in difficulties over the subject of preamps for low output pick-ups.

There is another point which we mention as a matter of interest for those who are looking forward to the early release of microgroove records in this country. The question of the upper resonance of the pick-up is all-important when it is placed in the high fidelity class, as is also the downward pressure of the point and the point radius. It is not generally known that the top resonance of a pick-up is only 50 per cent. of its value when fitted with .0025 points on shellac when used with L.P. on plastic, and this will account largely for the trend of certain manufacturers to use smaller armatures and lower outputs.

As far as we know Decca are the only other people (besides Brierley) to have considered this recently and they are getting out a new head as soon as possible with a reduced armature size and using two coil sizes.

The Brierley "Ribbon" has no measureable upper resonance, a downward pressure on the point of $\frac{1}{8}$ oz., and a point radius of .001 in. plus/minus 0.0002, this it is suitable for playing L.P. discs as well as standard records.

Another significant feature of the lightweight pick-up with vertical compliance is the almost entire absence of "talk" or "chatter."

The writer knows of one very expensive and impressive looking pick-up which on certain records can be heard up to about 20 feet away when the lid of the playing box is lifted!

Trusting the above may prove of some interest to you and with all good wishes to *Radio and Electronics*.—Yours etc.,

Auckland, 18th July. M. M. RHODES.

A High-Quality Amplifier

(Continued from Page 5.)

nected, and with the cathode resistor unbypassed. Under the conditions specified, this tube has a voltage gain of approximately 45 times, while the push-pull 6SN7 stage has a voltage gain of 14 times in each half. The 6V6s require a signal of approximately 20v. peak or 14v. R.M.S. for full output, so that without feedback, the voltage stages have enough gain to enable a signal of only 0.024v. R.M.S. to load the amplifier fully. Thus, with 20 db. of negative feedback applied, the full-load input signal voltage will be 0.25v. R.M.S. With smaller degrees of feedback, correspondingly smaller input signals will be needed for maximum output. This amount of gain is ample for almost all purposes to which the amplifier might be put. Very low-level pick-ups will, of course, need extra amplification, but there are not very many which do need more than this amplifier can give, and a good many of them will be able to be used with the official degree of bass boost, and yet without the provision of extra amplification.

Feedback is applied over the whole ampifier, from the voice-coil to the cathode of V_1. The exact value of the feedback resistor, R_{17}, will depend on the kind of output transformer used, and on the impedance of the speaker. Other things being equal, the lower the speaker impedance, the lower will be the value of R_{17}. We shall have more to say about this later on.

In purchasing an output transformer for this amplifier one should attempt to get the best possible value for money, both from the point of view of the cost, and that of the performance. It will be better, if difficulty is had in getting a small enough high-quality transformer to get a *good* large one. One solution which might prove satisfactory would be to use a cheap 20-watt P.A. type of transformer, for while these do not show up as high-fidelity components at their rated power input, they are reasonably good when the input power is limited to the four watts that this amplifier can give. However, the preceding trick is not one to be recommended where a better small transformer can be had. We ourselves have had one specially wound for the purpose, and this, while giving excellent results, is not expensive, because although it was designed to quite rigorous specifications, it is quite small, and uses much less of the expensive core material.

It will be noted that the grid leak resistors of the 6V6s have been kept low in value. The reason for this is two-fold. First of all, the valves are being used with fixed bias. As a result it is necessary to limit the grid circuit resistance to 100k. per valve in order to avoid blocking effects in the case of accidental signal overload. This is stipulated by the makers in their published data, and these points should always be respected if maximum valve life is a consideration. Secondly, and no less important the use of low-value grid leaks in the output stage has a very beneficial effect on the high-frequency response of the amplifier. Briefly, it reduces the effect of the triodes' comparatively high grid-plate capacity, due

to Miller effect, and prevents this capacity from causing undue phase shift, and also loss of gain at high audio frequencies. Because of the low value of the grid leaks, it is essential to use larger coupling condensers than usual, because of the los of low-frequency gain that would occur if small ones were employed. Again, because of thhe low-value grid leaks of the 6V6s, the plate load resistors of the drivers have to be reduced also, because good practice demands that the grid leak following a resistance-capacity-coupled amplifier stage should be at least twice the value of load resistor, especially if appreciable voltage output is required. The high power sensitivity of the 6V6s enables this arrangement to be used successfully, because it gives them their modest driving voltage requirement of 14v. R.M.S. With larger triodes, such as the 6A3, this would not be possible without the use of cathode-follower buffers, and this is the reason why we are able to eliminate the cathode followers in this circuit, without loss of quality compared with the "New High-quality Amplifier" circuit, where the EL37 output tubes, with higher plate voltage, needed greater signal driving voltage.

CONSTRUCTION

In Part II of this article we will give photographs of the complete amplifier, and will describe the construction and performance, with special reference to finding the correct degree of feedback to use with a given speaker, and thus the value of R_{17}, the feedback resistor.

The Philips Experimenter

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V_2 is a second ECC91. It is not used on the 50–54 mc/sec. band, but is brought in when the band-switch is operated, when it acts as a push-pull tripler, capacity coupled to the QV04/7 final amplifier. The switches Sw_1 and Sw_2 are ganged, being the sections of a single wave-change wafer. The first switches the input of the final amplifier to the output of V_1 for 50 mc/sec. operation, and to the output of V_2 for 144 mc/sec. The second switch connects the heater of V_2 for the 144 mc/sec. band, and disconnects it for the other. Since quick changes from band to band are hardly likely to be required, the short wait for the heater of V_2 to warm up will cause no inconvenience.

Because the final amplifier is capacity-coupled and single-ended, the push-pull output circuit of V_2 will be unbalanced when this stage is in operation, because only one side of the push-pull output circuit has the input capacity of the final connected across it. Thus, in order to get a better circuit balance in the plate of V_2, a small condenser, C_t, is connected from plate to ground on the opposite side to that which feeds the QV04/7. This is a Philips trimmer, and is readily adjusted by a method to be described later; the tripler's output is thus increased,

and more grid drive is available on 144 than if the balancing condenser had been omitted.

COIL DATA

L_1, 11 turns of 24-gauge enamelled wire, wound on a $\frac{3}{4}$ in. former, spaced to occupy $\frac{3}{4}$ in. Tap at one turn from the lower end.

L_2, 10 turns of 20-gauge enamelled wire, self-supporting, inside diameter $\frac{1}{2}$ in., spaced approximately one wire diameter.

L_3, 4 turns of 20-gauge enamelled wire, spaced to occupy $\frac{7}{8}$ in., inside diameter, $\frac{3}{8}$ in.

L_5 (50–54 mc/sec.), 6 turns of 20-gauge enamelled wire on a $1\frac{1}{8}$ in. ribbed polystrene former.

L_5 (144–148 mc/sec.), hairpin made of 16-gauge copper wire; spacing, $1\frac{1}{4}$ in., and overall height above chassis, $1\frac{3}{4}$ in.

(To be continued.)

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